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THE EFFECTS ON LEARNING FROM A MOTION PICTURE FILM OF SELECTIVE CHANGES IN SOUND TRACK LOUDNESS LEVEL. FINAL REPORT.

BY- MOAKLEY, FRANCIS X.
INDIANA UNIV., BLOOMINGTON, AUDIO-VISUAL CENTER

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EFFECTS OF PERIODIC VARIATIONS IN AN INSTRUCTIONAL FILM'S NORMAL LOUDNESS LEVEL FOR RELEVANT AND IRRELEVANT FILM SEQUENCES WERE MEASURED BY A MULTIPLE CHOICE TEST. RIGOROUS PILOT STUDIES, RANDOM GROUPING OF SEVENTH GRADERS FOR TREATMENTS, AND RATINGS OF RELEVANT AND IRRELEVANT PORTIONS OF THE FILM BY AN UNSPECIFIED NUMBER OF JUDGES PRECEDED THE EXPERIMENT. AN ANALYSIS OF VARIANCE FOR THE FOUR EXPERIMENTAL GROUPS SUGGESTED THAT HIGHER MEAN PERFORMANCE WAS A RESULT OF DECREASES IN LOUDNESS RATHER THAN INCREASES, REGARDLESS OF RELEVANCY OF THE MATERIAL. ANOTHER ANALYSIS SUGGESTED, HOWEVER, THAT DECREASES IN LOUDNESS FOR IRRELEVANT MATERIAL RESULTED IN HIGHER PERFORMANCE THAN DECREASES FOR RELEVANT MATERIAL. FOR THE THREE CONTROL GROUPS WHOSE FILM SEQUENCES WERE CONSTANTLY RELEVANT, MORE LEARNING RESULTED FROM LOUDNESS LEVELS BOTH ABOVE AND BELOW NORMAL THAN FROM A NORMAL LEVEL. HIGH PERFORMANCE LEVELS WERE POSITIVELY RELATED TO HIGH INTELLIGENCE LEVELS. THE BIASING EFFECTS OF EXPERIMENTAL NOVELTY AND UNNATURAL ATTENTION FACTORS WERE DISCUSSED. APPENDICES INCLUDE STUDENT RESPONSE SHEET, INSTRUCTIONS TO FILM JUDGES, FILM SCRIPT, INSTRUCTIONS TO SUBJECTS, AND FILM TEST. A BIBLIOGRAPHY IS GIVEN. (LH)

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Audio Visual Center
Indiana University
Bloomington, Indiana

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CHAPTER I

INTRODUCTION

Nature of the Problem

In the production of motion picture films, the use of pictorial attention-directing devices (e.g., questions posed to the viewer) and attention-directing methods (e.g., time of occurrence of such questions) has been the subject of many investigations. However, the use of audio attention-directing devices and methods is an area that has remained relatively unexplored by researchers. Several reviews of audio-visual research--Allen (1, 2, 3),* Lumsdaine (16), MacClennan (20), Travers (31), and May (22)--report only one study, Neu (26), in this latter area. The need for such research has been noted by Goyer (10) and Miller (24).

Some recent work in the area of pictorial research by Knowlton (15), and Payne (27) has been done with the intent of increasing the knowledge needed to design the pictorial aspects of films so that the films are intrinsically more relevant, rather than depending on the use of special extrinsic devices to sort out for the viewer the relevant portions.

Travers comments on this point as follows:

---

*Numbers in parentheses refer to numbered references in the bibliography; those after the colon are page numbers.

> The learner may ultimately have to learn to discriminate the relevant cues within the context of a realistic situation, though the internally occurring compression process may eliminate the need for learning. For example, a line drawing of the wiring of a television receiver is much more effective in transmitting information useful in assembling a kit than is a faithful photogram reproduction. The line drawing indicates at a glance the important features involved in wiring while the photogram requires careful study before the essential features can be sorted out from irrelevant features produced by shadow and shading. (31:9-17)

However, to clarify fully the visual elements of the film, normally one must turn to the film sound track. We may assume that a primary function of a film's narration is to serve to direct attention selectively to aspects of the visual presentation. As Travers puts it: "The commentary in many films is necessary only to help the viewer sort out the relevant from the irrelevant in the video presentation." (31:9-17)

Assuming that Travers' position is correct, the question arises as to what possible characteristics of the narration might serve to perform this attention-directing function. One such characteristic might be a variation in loudness level at critical points in the narration. It is commonly assumed that when speaking to an audience, we can increase attention to our message by raising or lowering our voice when we come to elements of the message we particularly wish to emphasize. The purpose of the present research was to investigate the effects on learning of such variations in the loudness level of a film sound track. It was hoped that the findings of this study would be of value to the producers of educational films.

Related Research and Literature

This section is divided into three parts, as follows: (a) a listing of selected resource materials concerned with the broad topic of the variables affecting learning from films; (b) a discussion of representative research studies concerned with the effects on learning of attention-directing devices and methods; and (c) a discussion of research studies concerned with the effects of audio attention-directing devices on film mediated learning.

Resource materials concerned with film variables. Reviews of research literature concerned with the variables affecting learning from films are numerous. Examples are Hoban (12), Allen (1,2,3), Butts (6), Lumsdaine (16), MacClennan (20), and Briggs (4). All of these have sections dealing with the use of attention-directing devices and methods in films.

Studies concerned with attention-directing devices and methods. In this section, studies representative of the various attention-directing devices and methods are described. Some of the studies described in this section are not unambiguous examples of the use of attention-directing devices. It is quite clear that in some of them the subjects were exposed to materials other than films from which they could have learned substantive information.

Wittich and Fowlkes (35) found a statistically significant difference in favor of class preparation over no preparation for films on social studies and science viewed by fourth, fifth, and sixth graders.

Vandermeer (33) used study guides before and after film viewings in one group and compared the performance of this group with a film-only group and a conventional-method group. No significant differences were found on tests of immediate recall, but the film/study guide group was superior to other groups on a retention test administered three months after the original learning and, for boys in the group, statistically significant.

Lumsdaine and Sulzer (18) found that the use of animated arrows and labels, for directing attention to key aspects of the picture and for interpreting the significance of cues, resulted in a statistically significant increase in the learning of micrometer reading with an adult audience.

Stein (30) found that the use of a pre-film test that was identical with a final test and that incorporated knowledge of results was statistically superior to methods in which students only viewed the film once, or twice in succession.

Northrup (25) investigated the effects on learning of adding organizational titles and commentary at appropriate points in instructional films. He found that the addition of titles and commentary to films significantly increased learning in those cases in which the film was not judged to be inherently well organized. Also, he found that simple outlines were just as effective as more detailed ones.

McIntyre (21) studied the effects of introducing humor in a training film. A comparison of two films, one with print titles giving cues to contents and the other with humorous comments and trick photography, statistically favored the print-titles version over the humorous version.

Lumsdaine (17), using elementary school and college students, conducted a series of experiments concerned with the directing of attention to certain parts of a film. Three techniques were used: attention directed by pre-test questions, attention directed by verbal instructions, and attention directed by a first viewing of a film and a discussion of the film prior to a second viewing of the film. All techniques were found to increase learning significantly in comparison with control-group conditions.

Kantor (14) and Vuke (33) studied the insertion of questions into a film commentary. Each of them found that inserted questions did not significantly increase learning from films when compared with a film without inserted questions.

Studies concerned with audio attention-directing devices. Zuckerman (36) discussed the implications of music in films. One of his opinions suggested a presumed value of music to direct attention in a film. However, as Travers (31) has pointed out, this opinion and many others are not supported by any research evidence.

Zuckerman (37) investigated amount of verbalization, kind of personal reference, and the nature of temporal phase relations between sound track and pictorial portions as elements of commentary variations in instructional films. He found that the lesser of two amounts of verbalization resulted in more learning, although not significantly so. Strong directive statements were found to increase learning as well as the use of the second person (you). Again, the differences were not statistically significant. Finally, he found that when the subject needed to be alerted to a particular visual detail, advance directions in the form of commentary lead was helpful. Once more, however, statistical significance was not obtained.

A study by Neu (26) has the most direct relation to the proposed research. He tested three hypotheses: (a) film-mediated learning is facilitated by relevant attention-gaining devices, (b) learning is equally facilitated by visual and audio attention-gaining devices of the same relevance, and (c) recall of the device is independent of the learning of film content. Five versions of a film dealing with the use of machine shop instruments were produced. Version one gave a straightforward presentation of the subject matter. Version two included additional visual material designed to direct attention to relevant portions of the film--material that might be described as intrinsic to the film (e.g., zoom to close-up). Version three included visual material that was extrinsic to the film (e.g., a still picture of a pretty girl). Version four had intrinsic auditory material added (e.g., naming of a tool when it was shown on the screen). Version five had extrinsic auditory material added (e.g., a squeaking door).

The subjects were 2,631 army recruits who were divided into five groups. Each of the five groups saw one of the five versions of the film. A post-test using both verbal and pictorial testing was employed. It was found that neither intrinsic nor extrinsic sound devices made a significant contribution to the learning of the trainees. In fact, the no-device version of the film was statistically superior to any other version. There was some indication, although not statistically significant, that the irrelevant audio attention-gaining devices inhibited learning. The lowest average score on the post-test was made by this group.

In Neu's study all of the audio attention-gaining devices were added to the original sound track. No attempt was made to substitute new for old aspects of the sound track in a manner designed to focus attention. Neu suggested the possibility of devising a technique that would provide the desired emphases without changing the film substantively. One way in which this could be done would be to vary the loudness level of the sound track. In the present study, the effect of such variation was examined.

Objectives

It was the purpose of the present study to investigate the effects upon learning of manipulating the relative loudness level of the sound track for portions of a film that vary with respect to their relevancy to a criterion test. The primary questions to be answered were as follows:

1. Does changing the loudness level of these portions of the sound track either in the upward or downward direction result in more learning if these changes occur during the presentation of relevant material than if these changes occur during the presentation of irrelevant material?

2. Does increasing the loudness level of portions of the sound track above a presumed normal loudness level result in more learning than decreasing the loudness level for these same portions?

3. Is the locus of changes in loudness level--*i.e.*, changes during the presentation of relevant material, on the one hand, or irrelevant material, on the other hand--

more important in the case of increasing the loudness level than in the case of decreasing the loudness level?

4. Assuming either that there is an interaction between direction and locus of loudness change or that changes in loudness level during the presentation of relevant material result in more or in less learning than comparable changes during the presentation of irrelevant material, does this latter relation hold specifically for increasing the loudness level?

5. Under the same assumptions as those made in Question 4, does this relation hold specifically for decreasing the loudness level?

6. Assuming that increasing the loudness level of portions of the sound track results in more or in less learning than decreasing the loudness level, does this relation hold specifically for the relevant material?

7. Does increasing the loudness level during the presentation of relevant material result in more learning than the use of the existing sound track at what is presumed to be normal loudness level?

8. Does decreasing the loudness level during the presentation of relevant material result in more learning than the use of the existing sound track at what is presumed to be normal loudness level?

In addition to these eight primary questions, a set of secondary questions has to do with level of intelligence and its interaction with the manipulated variables.

CHAPTER II

METHOD

Subjects

Four hundred and seventy-two subjects were available to the experimenter for the study. They were boys and girls from the seventh grade at Engvall and Parkside Junior High Schools in the San Bruno Park School District, San Bruno, California. All subjects were administered the California Test of Mental Maturity, Form 57-S. This provided an intelligence quotient for each child.

All students in the experiment were given hearing tests by an audiometrist. On the basis of these tests, 14 students were excluded from the experiment.

Seventy-two subjects, in two complete classes, whose mean I.Q. approximated the mean I.Q. of the 472 available subjects, were used in determining the reliability of the test used in the experiment. Seventy subjects, randomly selected from each of three I.Q. ranges, were used in pilot groups to select loudness levels to be used in the experiment. This left 316 subjects available to form experimental groups.

For each of seven experimental treatments, there was a separate group of subjects. Three of the groups were from Parkside School, and four were from Engvall School.

Division of the groups in this way was based on the fact that there was a larger number of students at Engvall School. The determination of particular treatments at the two schools and the order of presentation of treatments at each school was random. Three levels of I.Q. were established. These were arbitrarily labeled Very Superior (118 and above), Superior (104-117), and Average (103 and below). Students from each I.Q. level at each school were randomly assigned in equal numbers to the treatments that had been assigned to the school. Sixty-four subjects were randomly discarded at this point to achieve groups of manageable size. Thus, 36 subjects remained in each of the seven treatment groups. Due to the fact that many students were absent on the days that the experiment was conducted, an additional 42 subjects were randomly discarded in such a way as to maintain proportionality of cell frequency. Thus the treatment groups were reduced in size to 30 subjects each, totalling 210 subjects.

As can be seen in Table 1, from one experimental group to another, the means and variances of the I.Q. scores were approximately equal. Thus, random assignment of subjects to experimental conditions did not result in any gross differences between experimental groups with respect to I.Q.

TABLE 1. MEAN, STANDARD DEVIATION, AND RANGE OF I.Q. SCORES FOR EACH OF THE SEVEN GROUPS FORMED FOR THE STUDY

Group	Mean	S.D.	Range
1	111.5*	13.49	79-141
2	111.2	16.27	81-142
3	112.0	11.57	84-141
4	107.5	14.69	68-132
5	110.2	13.8	82-139
6	110.5	14.8	85-141
7	110.8	17.46	78-150

*Each of the entries in the table is based upon the I.Q. scores of 30 subjects.

Stimuli

The film. The film used in the experiment was entitled "Time." It was produced by Fleming (9) in an earlier experiment concerned with the application of programmed instruction principles in the production of films.

Selection of the film was, in part, arbitrary. An important advantage was the availability of a test of comprehension of its context that had a rather high degree of reliability. Also, this film, in contrast with most other films, was based upon considerable experimental work. Hopefully, the present study adds to the experimental data concerned with this film.

Each section of the film had a separate set of test questions covering concepts presented in that section of the film. Subjects were tested after each section of the film was viewed, rather than at the completion of the film. The concepts treated in the film were common to the science curriculum of the seventh grade in California public schools as determined by an examination of course outlines. Thus, presumably the content of the film was appropriate for students at this grade level.

The original version of the film had seven sections. Judges participating in the present study agreed that concepts in the first five sections were closely related to each other, but they also agreed that the last two sections of the film were discontinuous with the subject matter presented in the earlier sections. At their suggestion, the last two sections of the film were not shown in the experiment.

The _test_. The test used was the same as that used by Fleming (9), with the exception of the last 10 questions, which covered the last two sections of the film. In the present study, these 10 questions were omitted.

In Fleming's study, test booklets had 4" x 5" sheets of paper with plastic binding. For the present experiment, the test was reproduced on 8½" x 11" sheets that were punched and inserted in three-ring looseleaf binders. This change was made with the intent (a) to promote easier handling of the test booklet and answer sheet by subjects, (b) to increase protection from subjects' observing other subjects' written responses, and (c) to provide a format that would allow rapid change of test booklet pages should subjects write on them.

Fleming, using a Kuder-Richardson formula for test reliability, reported an r of .75. Two classes of 36 students each, other than subjects assigned to experimental groups, were given the test for the purpose of verifying its reliability. The same computational formula resulted in a r of .78. The 95 per cent confidence interval for this r has a range from .66 to .86. The last 10 items of the original Fleming test were not used in the computation of the r in the present study.

In the pilot study, students used mark-sense cards to record their answers. The card design was such that students were making errors in recording their response. To lessen this problem, an answer sheet was constructed that matched the number of required responses with the number of questions for each section of the film, with a rather large space being left between blocks of items on the answer sheet. The answer sheet is shown as Appendix A.

Loudness levels of the sound track. The experimental design involved changes in loudness level of the sound track that were correlated with portions of the sound track judged to be "relevant" or "irrelevant." A tape was dubbed from the film sound track using a high-quality tape recorder. Then, using a special tape recorder that permitted control of loudness level ("mixer"), a tape recording of the sound track was made with the recording level of the mixer set at -10 db. This tape was then played, for convenience, on a portable (Wollensak) tape recorder to a pilot group of 10 subjects, one at a time, who listened to the tape recorder through a headset. The volume scale was set at 4.6 and the tone level at mid-normal. All 10 subjects independently indicated that these settings produced a comfortable listening level. The loudness level of this tape will be subsequently referred to as "normal." These settings on the tape recorder were maintained unchanged for the remainder of the study.

Using a criterion of 100 per cent correct detection of an increase in the loudness of the sound track when it occurred, six pilot tests, involving 60 subjects altogether, with subjects being used one at a time, were conducted to select a second loudness level of the sound track higher than the normal level.

Five additional tapes were made, with settings on the volume units ("B") scale of the mixer being increased by seven units for each tape. Thus, the loudness level increased by two db with each successive tape. A shift of 10 db above the initial point of -10 db met the criterion of all subjects in a pilot group's being able to identify the changes in loudness level when they occurred.

In order to select a loudness level lower than the normal level, a tape was made at -20 db. Whereas the higher (0 db) loudness level was 10 db _above_ normal, the -20 db level was 10 db _below_ normal. All subjects in a single pilot group independently met the criterion of 100 per cent correct identification of loudness changes when they occurred.

With the loudness levels established at -20, -10, and 0 db, a tape was made at -20 db and one was made at 0 db. These tapes, together with the tape that had been made at -10 db, were used with three control groups for whom loudness level was held constant, as shown in Table 2. Four additional tapes were made. Each of these tapes involved periodic loudness changes, as described in Table 3. These tapes were made by additional recording, and cutting and splicing, followed by additional recordings free of splices.

TABLE 2. LOUDNESS LEVEL AND LOCUS AND DIRECTION OF LOUDNESS LEVEL CHANGES OF THE THREE CONTROL GROUPS

Control group	Loudness level	Locus and direction of loudness level changes
Group 1	-10 db	Constant-no changes
Group 2	-20 db	Constant-no changes
Group 3	0 db	Constant-no changes

TABLE 3. LOUDNESS LEVEL AND LOCUS AND DIRECTION OF LOUDNESS LEVEL CHANGES OF THE FOUR EXPERIMENTAL GROUPS

Experimental group	Loudness levels	Locus and direction of loudness level changes
Group 1	-10 and 0 db	Increased 10 db below normal when relevant material was heard.
Group 2	-10 and -20 db	Decreased 10 db below normal when relevant material was heard.
Group 3	-10 and 0 db	Increased 10 db above normal when irrelevant material was heard, but duration and spacing of loudness levels approximated that of Group 1.
Group 4	-10 and -20 db	Decreased 10 db below normal when irrelevant material was heard, but duration and spacing of loudness levels approximated that of Group 2.

Script preparation. A group of three science educators independently viewed the film and independently read the test and script. Using the test as a guide, they were instructed to underline the relevant portions of the script--*i.e.*, those portions that in their opinion were expressly needed in order for the subject to be able to answer the test questions correctly. Detailed instructions to the group are found in Appendix B. The underlining of a portion of the text by two of the three members of the group was considered necessary and sufficient for the material to be considered as "relevant." Appendix C shows the script with the relevant portions underlined. Twenty-five and seven-tenths per cent of the script was judged to be relevant.

A portion approximating the relevant percentage was underlined in the remaining, "irrelevant," portions of the script by this writer. In so far as it was possible, the underlining approximated the temporal spacing already chosen by the judges in the relevant sections. The script with this treatment is shown in Appendix D. These scripts served as the basis for preparing tapes that were to change periodically in loudness level.

Apparatus

The film used in the study was shown on a Model 552 Bell and Howell Autoload 16mm projector. Students listened to the narration on Switchcraft Model 3825 headsets, connected in parallel through a junction box and individually adjusted to approximately the same loudness level. A Wollensak monaural tape recorder, Model T-1500, was used to play the tapes.

The master tapes for use in the study were prepared in the Audio Department, San Francisco State College, by an audio technician. A master tape was recorded from the film sound track at 3 3/4 IPS, half-track, using an Ampex tape recorder, Model 340. An Alter Mixer Amplifier, Model 1567A was used to change the loudness level of the master tape to the three sound levels listed in the preceding section.

Procedure

The experiment was conducted during the regular school hours in the multi-purpose classrooms at Engvall School and Parkside School. Each school's multi-purpose room is of the same size and configuration, allowing the arrangement of the experimental apparatus to be the same in both schools. Table 4 shows times and conditions for both schools. All subjects in a given experimental group were tested at the same time. Subjects arrived at the multi-purpose room at the time scheduled for their group. No formal seating plan was used. At each student position was a pencil, an answer sheet, a test booklet and a headset.

TABLE 4. SCHEDULE OF EXPERIMENTAL TREATMENTS AT BOTH SCHOOLS

School*			
Engvall Junior High**		Parkside Junior High	
Treatment	Time	Treatment	Time
-20 db constant	8:30 am	-10 and 0 db; increase, relevant	9:00 am
-10 and -20 db; decrease, irrelevant	9:30 am	-10 and -20 db; decrease relevant	10:00 am
-10 and 0 db; increase, irrelevant	10:30 am	0 db constant	11:00 am
-10 db constant	1:30 pm		

*The Engvall Junior High School was visited on June 7, 1967. The Parkside Junior High School was visited on June 9, 1967.

**The experiment was conducted in the multi-purpose room of each school, the rooms having similar configurations.

Each subject listened to the sound portion of the film via his own headset.

Subjects were both told and shown how to wear the headsets. (Appendix F consists of the detailed instructions to subjects.) Then they viewed the first segment of the film. After the completion of each segment of the film, the subjects answered questions contained in their test booklets about the content of that segment of the film, recording their responses on the answer sheet. All questions in the test were multiple-choice ones. After each segment, the film was not resumed until the times shown in Table 5 had elapsed. This table was empirically derived from both the timing of the film segments and from observing the maximum amount of time that subjects participating in the pilot study required to answer the questions for each segment.

TABLE 5. SCHEDULE OF EVENTS AND ELAPSED TIMES FOR EVENTS FOR ALL SEVEN GROUPS

Event	Time
Explanation/Introduction to the Experiment	3 minutes
Film Section 1	1 minute 23 seconds
Answer Time	3 minutes
Film Section 2	3 minutes 11 seconds
Answer Time	5 minutes
Film Section 3	3 minutes 54 seconds
Answer Time	5 minutes
Film Section 4	5 minutes 33 seconds
Answer Time	5 minutes
Film Section 5	2 minutes 34 seconds
Answer Time	4 minutes
Total Time	41 minutes 35 seconds

The independent variables were the locus of loudness change, the direction of loudness change, the loudness level in those groups where loudness remained constant throughout the film and the level of intelligence. The dependent variable was the number of correct responses made on the film test. A response was considered correct if the correct answer was chosen on the thirty-item multiple-choice test. A response was considered incorrect if the subject either failed to answer the question, or chose the wrong answer. When the experiment was concluded, the subjects were cautioned not to discuss the experiment with other students, thanked for their assistance and asked to return to class.

Design

The primary part of the study involved a combination of the variables locus of loudness change, direction of loudness change and level of intelligence, in a 2 x 2 x 3 factorial design. In addition, a comparison was made involving the combination of the variables of loudness level where level remained constant and level of intelligence, in a 3 x 3 factorial design. Finally, comparisons were made between all seven of the experimental and control groups using a Duncan Multiple Range Test. The primary design is represented in Figure 1. The design for the comparisons of the control groups is represented in Figure 2. The case of comparisons made using the Multiple Range Test is not represented because of its simplicity.

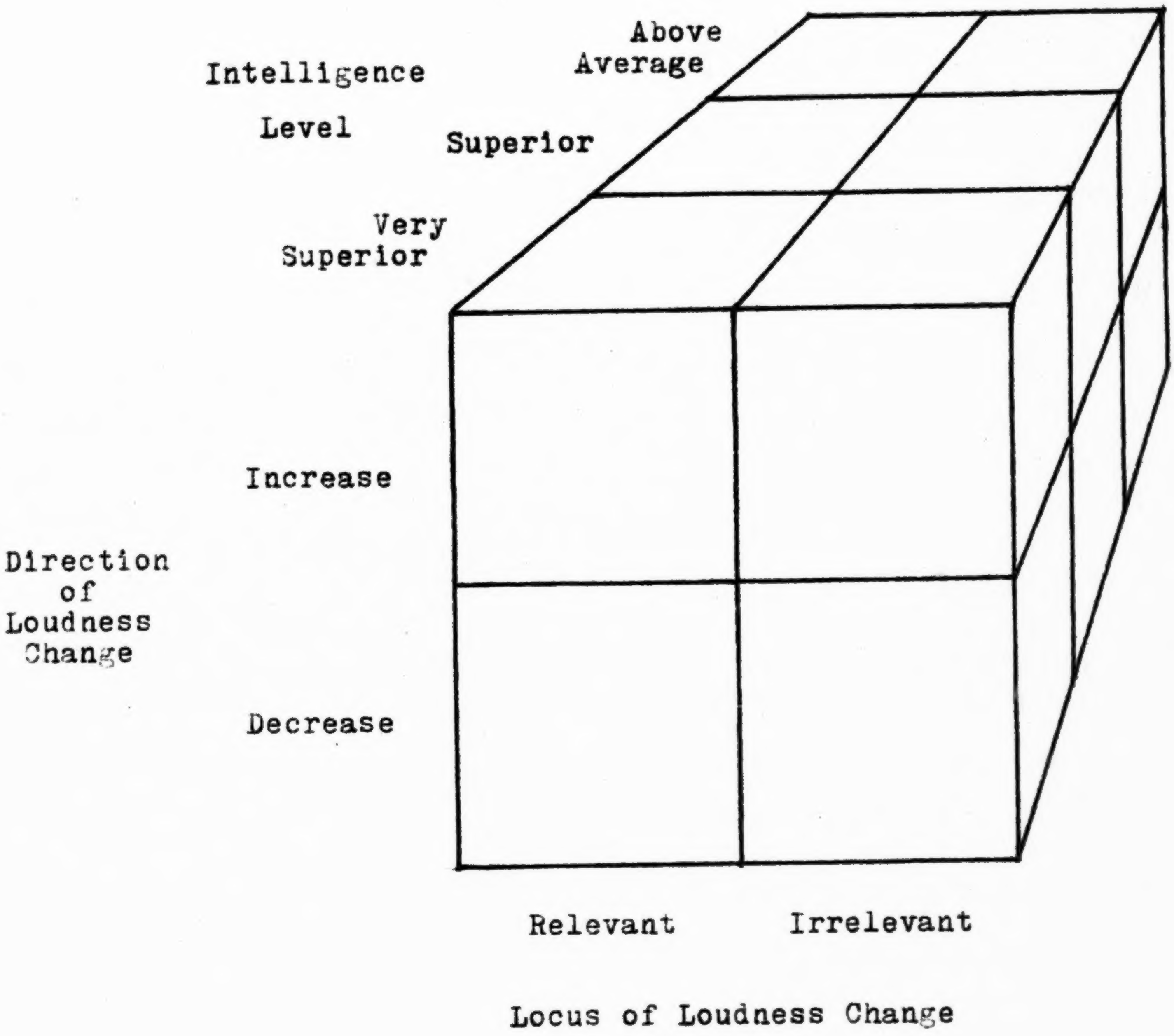

Intelligence
Level
Above
Average
Superior
Very
Superior
Increase
Decrease
Direction
of
Loudness
Change
Relevant
Irrelevant
Locus of Loudness Change

Figure 1. Two by Two by Three Factorial Design for Direction of Loudness Change by Locus of Loudness Change by Intelligence Level

Intelligence Level

Loudness Level		Very Superior	Superior	Above Average
	High			
	Normal			
	Low			

Figure 2. Three by Three Factorial Design for Loudness Level by Intelligence Level

CHAPTER III

RESULTS

Table 6 presents the mean number of correct responses, the standard deviation, and the standard error of the mean for each experimental and control group.

TABLE 6. MEAN CORRECT RESPONSES, STANDARD DEVIATION, AND STANDARD ERROR FOR EACH EXPERIMENTAL AND CONTROL GROUP

Group	Sound levels	Nature of change in sound level	Mean	S.D.	S.E. mean
EXPERIMENTAL GROUPS					
Group 1	-10 db and 0 db	Increase over relevant portions	16.6	4.07	.74
Group 2	-10 db and -20 db	Decrease over relevant portions	18.0	4.32	.80
Group 3	-10 db and 0 db	Increase over irrelevant portions	17.8	4.53	.83
Group 4	-10 db and -20 db	Decrease over irrelevant portions	19.5	4.70	.87
CONTROL GROUPS					
Group 1	-10 db	Constant	16.9	4.25	.76
Group 2	0 db	Constant	19.6	4.25	.76
Group 3	-20 db	Constant	19.2	3.88	.71

Comparisons Between Experimental Groups

A 2 x 2 x 3 factorial analysis of variance was applied to determine the separate and joint effects of three of the independent variables and is summarized in Table 7.

TABLE 7. SUMMARY OF ANALYSIS OF VARIANCE FOR EXPERIMENTAL GROUPS

Source of variation	SS	df	MS	Required .05 value	F
A Locus of loudness change	52.2	1	52.2	3.92	3.53
B Direction of loudness change	78.7	1	78.7	3.92	5.32*
C Intelligence level	600.0	2	300.0	3.07	20.27*
AB	.3	1	.3	3.92	.02
AC	4.3	2	2.2	3.07	.15
BC	5.3	2	2.7	3.07	.18
ABC	43.1	2	21.5	3.07	1.45
Within treatments	1,601.1	108	14.8		
Total	2,385	119			

*Significant at the .05 level.

An application of Bartlett's test for homogeneity of variance did not result in rejection of the null hypothesis at the 5 per cent level. The decision was made to adopt a critical region for rejecting the null hypothesis in the analysis corresponding to the 5 per cent level of significance.

Locus of loudness change. The percentage of correct responses made by the two groups where the locus of loudness change was coordinate with relevant material was 57. The percentage of correct responses made by the two groups where the locus of loudness change was coordinate with irrelevant material was 62. Stated in terms of mean number of correct responses, the groups having a locus of loudness level coordinate with relevant material had a mean of 17.3 and the groups having a locus of loudness level coordinate with irrelevant material had a mean of 18.7. The difference between these means was not statistically significant. Thus, there was no evidence that the locus of the loudness change influenced performance.

Direction of loudness change. The percentage of correct responses made by the two groups that had periodic increases above the normal loudness was 58. The percentage of correct responses made by the two groups that had periodic decreases below the normal loudness was 63. Stated in terms of mean number of correct responses, the groups having increases above normal loudness had a mean of 17.2.

The groups having decreases below normal loudness had a mean of 18.8. The difference between these means was statistically significant. Thus, performance was significantly better when there were periodic decreases below the normal loudness than when there were periodic increases above the normal loudness.

Intelligence level. The percentage of correct responses made by the average, superior and very superior subjects were, respectively, 51 per cent, 60 per cent, and 69 per cent. Stated in terms of mean number of correct responses, the results were as follows: average, 15.2; superior, 18.0 and very superior 20.7. The difference between these means was statistically significant. Thus performance increased significantly as a function of increasing level of intelligence.

Interaction between locus of loudness change and the direction of loudness change. The *F* for the interaction between the locus of loudness change and the direction of loudness change was not significant. Thus, the difference between the mean number of correct responses as a function of locus of loudness change did not vary significantly as a function of the direction of loudness level change. This also indicates, of course, that difference between the mean number of correct responses as a function of the direction of loudness level change did not vary significantly from one locus of loudness change to another.

Interaction between locus of loudness change and intelligence level. The *F* for the interaction between locus of loudness change and intelligence level was not significant. Thus, the difference between the mean number of correct responses as a function of locus of loudness change did not vary significantly from one intelligence level to another. This also indicated, of course, that the difference between the mean number of correct responses as a function of intelligence level did not vary significantly from one locus of loudness change to the other.

Interaction between direction of loudness level change and intelligence level. The *F* for the interaction between direction of loudness change and intelligence level was not significant. Thus, the difference between the mean number of correct responses as a function of direction of loudness level change did not vary significantly from one intelligence level to another. This also indicates, of course, that the difference between the mean number of correct responses as a function of intelligence level did not vary significantly from one direction of loudness change to another.

Interaction between locus of loudness change, direction of loudness change and intelligence level. The *F* for the three-way interaction of locus of loudness change, direction of loudness change and intelligence level was not significant. Thus, differences between the locus of loudness change by direction of loudness level change interaction did not differ significantly from one intelligence level to another. Also of course, the difference between the locus of loudness change by intelligence level interaction did not vary significantly from one direction of loudness change to another. And finally, the difference between the direction of loudness change by intelligence level interaction did not vary significantly from one locus of loudness change to another.

Summary of the primary effects. Of the eight primary research effects studied, two were significant at the .05 level; namely, direction of loudness level change and intelligence level. Those effects which were not significant were locus of loudness change, the interaction of locus of loudness change and direction of loudness level change, the interaction of locus of loudness change and intelligence level, the interaction of direction of loudness level change and intelligence, and the three-way interaction of locus of loudness change, direction of loudness level change and intelligence level.

Comparisons Between Control Groups

A 3 x 3 factorial analysis of variance was applied to determine the separate and joint effects of two independent variables and is summarized in Table 8. An

TABLE 8. SUMMARY OF ANALYSIS OF VARIANCE FOR CONTROL GROUPS

Source of variation	SS	df	MS	Required .05 value	*F*
A Loudness level	126.1	2	63.05	3.11	4.36*
B Intelligence level	310.05	2	155.2	3.11	10.72*
AB	3.34	4	8.35	2.48	.48
Within treatments	1,172.4	81	14.47		
Total	1,612.3	89			

*Significant at the .05 level.

application of Bartlett's test for homogeneity of variance did not result in rejection of the null hypothesis at the 5 per cent level. The decision was made to adopt a critical region for rejecting the null hypothesis in the analysis corresponding to the 5 per cent level of significance.

Loudness level effect. The percentage of correct responses made by the group that listened to the sound level at the normal level, constant throughout the tape, was 56. The percentage of correct responses made by the group that listened to the sound level at the higher level, constant throughout the tape, was 65. The percentage of correct responses made by the group that listened to the sound level at the lower level, constant throughout the tape, was 64. Stated in terms of mean number of correct responses, the results were as follows: normal level, 16.9; higher level, 19.6 and lower level, 19.2. The difference between these means was statistically significant. Thus performance was significantly better at both the higher and lower levels than at the normal level.

Intelligence level effect. The percentages of correct responses made by the average, superior and very superior subjects were, respectively, 54 per cent, 62 per cent and 69 per cent. Stated in terms of mean number of correct responses, the results were as follows: average, 16.2; superior, 18.7 and very superior, 20.7. The difference between these means was statistically significant. Thus, performance increased significantly as a function of increasing level of intelligence. This result is the same as, but independent of, the result obtained in the earlier analysis involving the four experimental groups.

Interaction between constant loudness level and intelligence level. The *F* for the interaction between constant loudness level and intelligence level was not significant. Thus difference between the mean number of correct responses as a function of constant loudness level did not vary with respect to intelligence level. This also indicates, of course, that the differences between the mean number of correct responses as a function of intelligence level did not vary significantly from one constant loudness level to another.

Comparisons Between the Four Experimental and the Three Control Groups

The Duncan multiple range test was used to make comparisons between all seven groups in the study. Table 9 presents a factorial analysis combining all values of all independent variables with the exception of intelligence level. This analysis is necessary to obtain the mean square within treatments needed in the application of the Duncan multiple range test. Results were pooled over

TABLE 9. SUMMARY OF ANALYSIS OF VARIANCE FOR ALL GROUPS

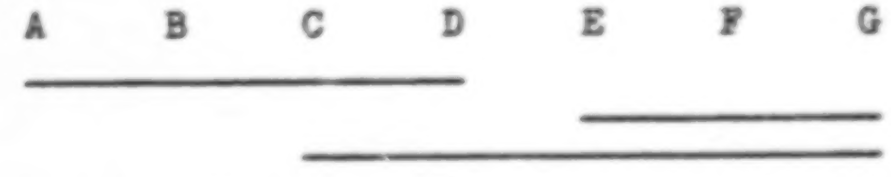
Source of variation	SS	df	MS	Required .05 value	*F*
A Intelligence	890.4	2	445.2	3.07	30.23*
B Loudness change and locus of loudness change	273.4	6	45.6	2.17	3.09*
AB	69.4	12	5.68	1.83	.39
Within treatments	2,782.8	189	14.7		
Total	4,016.0	209			

*Significant at .05 level.

intelligence levels. The decision was made to adopt a critical region for rejecting the null hypothesis in the analysis corresponding to the 5 per cent level of significance. Table 10 shows the application of the multiple range test to the means of all the groups in the experiment.

TABLE 10. DUNCAN MULTIPLE RANGE TEST FOR THE FOUR EXPERIMENTAL AND THE THREE CONTROL GROUPS

Means	A 16.6	B 16.9	C 17.8	D 18.0	E 19.2	F 19.5	G 19.6	Shortest significant ranges
A 16.6		.3	1.2	1.4	2.6	2.9	3.0	R_2=1.96
B 16.9			.9	1.1	2.3	2.6	2.7	R_3=2.07
C 17.8				.2	1.4	1.7	1.8	R_4=2.14
D 18.0					1.2	1.5	1.6	R_5=2.18
E 19.2						.3	.4	R_6=2.23
F 19.5							.1	R_7=2.25



Any two treatment means not underscored by the same line are significantly different.

Any two treatment means underscored by the same line are not significantly different.

Table 11 lists the comparisons between groups that were significant at the 5 per cent level.

TABLE 11. SUMMARY OF SIGNIFICANT EFFECTS AS SHOWN ON THE DUNCAN MULTIPLE RANGE TEST FOR THE FOUR EXPERIMENTAL AND THE THREE CONTROL GROUPS

Means	Significance
19.6-16.6	Constant high loudness level significant over high relevant loudness level.
19.6-16.9	Constant high loudness level significant over constant normal loudness level.
19.5-16.6	Low irrelevant loudness level significant over high relevant loudness level.
19.5-16.9	Low irrelevant loudness level significant over constant normal loudness.
19.2-16.6	Constant low loudness level significant over high relevant loudness level.
19.2-16.9	Constant low loudness level significant over constant normal loudness.

CHAPTER IV

DISCUSSION

The results will be discussed in relation to and in the same order as the eight primary research questions and the secondary questions, the latter being concerned with intelligence.

The failure to find periodic changes in loudness over relevant portions of the sound track to result in significantly more learning than changes over irrelevant portions was quite unexpected. This result suggests that the presumption that importance would be attached to emphasizing specifically the relevant material was not confirmed.

The fact that periodic decreases in loudness resulted in significantly more learning than periodic increases was even more unexpected in view of the fact that this result was exactly opposite to the expected result. One might speculate that the periodic increases in loudness above normal were aversive to the subjects. In the pilot studies emphasis was placed upon the reliable detection of loudness changes rather than upon the comfort of the subjects. If the increase in loudness level was aversive, it may be further speculated that the periodic upward changes to an uncomfortable loudness level would have a distracting effect, resulting in subjects' failing to attend as closely as otherwise to the material to be learned. It is plausible that this distracting effect operated regardless of the locus of the loudness increases, which is in keeping with the absence of an interaction between the direction and the locus of loudness changes. One may speculate in addition that subjects for whom there were periodic decreases in loudness below normal were periodically "forced" to listen more carefully in order to hear the material on the sound track and that this fact in itself resulted in more attentive behavior. Finally, it should be pointed out that the precaution of using a "loudness compressor" to minimize distortion was not taken in the process of making the tapes. The consequence of this fact is that distortion in the sound track may have been especially great at the above-normal loudness. Hence, distortion as well as aversiveness may have occurred where periodic increases above normal loudness occurred. On the other hand, it may be recalled that where loudness was constantly above normal, test performance reached its highest level. Thus, one might conclude that distortion and aversiveness were not factors affecting learning. However, one might argue that in the case where loudness was constantly above normal, subjects might have quickly learned to cope with the problem of distortion and have quickly adapted to the high loudness level and thus were less affected than subjects who were exposed to such a loudness level only periodically.

Clearly, the issue cannot be resolved without additional research designed specifically to investigate the effect of the extent of distortion and aversion present.

The failure to find a significant interaction between the locus and the direction of loudness changes shows that the significant difference found as a function of direction of loudness changes was invariant with the locus of these changes.

Since the assumptions permitting answers to experimental questions four, five, and six were not met, these questions will not be discussed further.

The failure to find periodic increases above normal loudness, specifically over relevant portions of the sound track, to result in significantly more learning than the use of a sound track at what was presumed to be normal loudness may be explained tentatively on the basis of possible aversiveness and distortion as discussed above in connection with the effect of direction of loudness changes. In any event, this particular comparison provided no evidence of a facilitative effect of loudness changes.

The failure to find a significant difference in the similar comparison between the occurrence of periodic decreases over relevant portions and normal loudness might be said to be consonant with the view that the significant superiority of decreasing below normal loudness to increasing above normal loudness was perhaps due to a combination of the aversive or distortion factor for increases and the attention-getting characteristic of decreases. That is, in the present comparison only one of these postulated factors could be present--*viz*., the attention-getting characteristic of decreases--in view of the fact that one of the conditions being compared involved a constant normal loudness. Thus, the magnitude of the effect of the postulated attention-getting characteristic may be too small to yield statistical significance.

The fact that in two independent statistical analyses, test performance was significantly greater at higher levels of intelligence was not surprising. The primary purpose for incorporating level of intelligence as a variable was to reduce error variance in the statistical analyses. The failure to find any of the interactions between level of intelligence and the manipulated variables to be significant implies, of course, that the significant differences that were obtained in the study do not have to be qualified with respect to level of intelligence.

Although not a formal part of the objectives of the study, certain additional comparisons between experimental and control groups presented in the Results section (Table 11) will now be discussed.

The significant superiority of constant high loudness of periodic increases above normal loudness during the presentation of relevant material may be tentatively attributed in part to the presumed aversiveness of these increases. An additional contribution to this effect could have been due to an attention-getting characteristic of the constant high loudness. This latter possibility is suggested, for example, by the significant superiority of constant high loudness to constant normal loudness.

The significant superiority of periodic decreases over irrelevant material to both increases over relevant material and to constant normal loudness is somewhat inconsistent with not only other results in the study but also with suggested explanations of these results. For example, one would expect that if decreases over irrelevant material were superior to increases over relevant material, decreases over relevant material would also be superior to increases over relevant material. One reason for this expectation is that there was no evidence in the 2 x 2 x 3 analysis of variance that decreases over relevant material and decreases over irrelevant material affected performance differently. Further, on the basis of this lack of evidence together with the superiority of decreases in loudness over increases in loudness, it was presumed that the occurrence of periodic decreases below normal in loudness, regardless of locus, had a facilitating effect in part because of an attention-getting function of the low loudness level. Other examples similar to the present one could be given. However, the example just given along with the other possible examples may be succinctly summarized in the statement that performance under the condition of decrease over irrelevant material was "too high." This result is anomalous when it is considered in relation to other results and suggested explanations, and no resolution of this difficulty has been achieved by the writer.

The significant superiority of constant low loudness to increases over relevant material is consonant with prior explanations in terms of the attention-getting function of the low loudness level and the aversiveness or the distortion occasioned by increases above normal loudness. The first of these two explanations is consonant with the significant superiority of constant low loudness over constant normal loudness.

As for the relation of the present results to those of Neu (26), the most general statement that can be made is that whereas Neu found that several types of departure from the normal sound track resulted in significantly less learning, several of the departures from the normal sound track in the present study resulted in significantly more learning, and none resulted in significantly less learning. All of Neu's departures represented the addition of new audio or visual material, whereas in the present study this was not the case, of course. In the present study, two kinds of departure from normal led to significantly greater learning--viz., the introduction of periodic changes in loudness, with some exceptions, and the adoption of a constant loudness either above or below the normal loudness. The former may be said to be more nearly analogous to Neu's procedure, although the latter resulted in increased learning as great as that resulting from the former. Both of these had the desired effect of increasing the amount of learning. Therefore, it would appear that attention-getting techniques that do not involve the addition of new material may be more successful in some instances.

Finally, it should be noted that both kinds of techniques used in the present study that resulted, in some instances, in increased learning might be described as having the characteristic of novelty. It is a well-known fact that novelty may increase attention (Berlyne in Travers). It could be that in the present study the increases in learning were due to a novelty effect and that continued exposure of subjects to the conditions that led to these increases would result in the disappearance of the facilitating effect.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

An experiment was conducted with junior high school students to determine the effect of four variables on the amount of learning from a motion picture film. The purpose of the experiment was to determine the separate and in some instances the joint effects on amount of learning of (a) the direction of periodic changes above or below "normal" in the loudness level of the sound track of the film, (b) the locus of these loudness changes, (c) the loudness level where loudness remained constant throughout the film, and (d) level of intelligence.

Seven tapes of the film's sound track, with variations in their characteristics coordinate with the experimental design, were played with the film to seven different groups of subjects at each of three levels of intelligence. There were 210 subjects. Subjects listened to the tape through a headset. The subjects' task was to answer questions on a multiple-choice test at periodic breaks in the film showing.

The preparation of the tapes was accomplished in two steps. First, a panel of judges viewed the film and read the script and text. Following this, the judges were asked to underline those portions of the script that they felt necessary for a student to answer correctly the items on the criterion test. Two out of three judges had to underline the material for it to be considered "relevant." They underlined approximately 25.7 per cent of the script. The material so underlined became the relevant information in the film for the purposes of the experiment. The experimenter then underlined in the remaining, "irrelevant," material portions of the script approximating the frequency of occurrence and length of the relevant material.

The second step in preparing the tapes was the establishing of loudness levels. This was done by a series of pilot tests, where subjects, individually tested, reached common agreement on a "normal" level; and a determination was made as to the amounts of increase above normal and decrease below normal that were required in order to achieve 100 per cent detectability. The loudness levels were established as -10 db, normal; 0 db, the loudness level higher than normal; and -20 db, the loudness level lower than normal. Four separate tapes were prepared for combinations of the values of two manipulated independent variables as follows: increases in loudness coordinate with relevance; decreases in loudness coordinate with relevance; increases in loudness coordinate with irrelevance, and decreases in loudness coordinate with irrelevance. These increases and decreases in loudness were with respect to normal loudness. Three additional tapes were made with loudness constant at the three established loudness levels. These tapes corresponded to a third manipulated independent variable. These seven tapes constituted the different sound tracks that subjects listened to during the experiment.

The data obtained from a combination of the three variables direction of loudness changes, locus of loudness changes, and level of intelligence were subjected to a 2 x 2 x 3 analysis of variance; data from a combination of the two variables loudness level where loudness remained unchanged, and level of intelligence were subjected to a 3 x 3 analysis of variance and data obtained from all seven of the conditions established through experimental manipulation was subjected to analysis using a Duncan multiple range test.

The 2 x 2 x 3 analysis of variance showed the following effects to be significant at the .05 level: (a) periodic decreases in loudness resulted in higher mean performance than periodic increases in loudness, and (b) higher intelligence levels were accompanied by higher mean performance. The 3 x 3 analysis of variance showed (a) that both the constant loudness level above as well as the constant loudness level below what was presumed to be a normal loudness level resulted in significantly higher mean performance, and (b) as in the 2 x 2 x 3 analysis, that higher intelligence levels were accompanied by higher mean performance. The Duncan multiple range test showed that decreases in loudness coordinate with irrelevant material, the constant loudness level above normal level and the constant loudness level below normal level all resulted in significantly higher mean performance at the .05 level than both increases in loudness coordinate with relevant material and the constant normal loudness level.

Conclusions

The conclusions drawn from the present study are presented below. It is to be understood when not specifically mentioned that the conclusions are subject to qualification with respect to the unique conditions of the study. Generalization of the findings must be cautious since the subjects were not selected randomly from any population, subjects were from only one grade level, only one film was used, and the range of values of loudness levels used was restricted. Clearly, other unique characteristics of the present study might be enumerated.

The specific conclusions drawn are as follows:

1. The locus of loudness changes had no apparent effect on learning, although this conclusion is not entirely firm. Although one analysis led to this conclusion, another analysis suggested that periodic decreases

in loudness over irrelevant material resulted in a greater increase in learning compared with constant loudness level than did periodic decreases over relevant material.

2. The direction of loudness changes did have an effect on learning, although in the opposite direction to that which was anticipated. Decreases below normal loudness resulted in more learning than increases above normal.

3. The difference in amount of learning as a function of the direction of loudness changes was invariant with the locus of these changes, although this conclusion is not entirely firm for the same reason that the first conclusion is not.

4. When loudness remained constant throughout the sound track, levels of loudness above and below normal loudness resulted in more learning than did normal loudness.

5. Higher intelligence levels were accompanied by more learning, and the experimental effects were invariant with level of intelligence.

Recommendations

The recommendations that the writer would like to make are of three kinds--*viz*., suggestions for extension of the present research, suggestions for solutions of certain methodological problems that arose, and suggestions to film producers as to how the results of the present study might be applied.

A potentially promising extension of the present research might be accomplished through the application of the present techniques to a film that was deliberately planned for experimental purposes. Since the sound track of the film used in the present study was not designed to differ systematically in relevancy,. it could be that the failure to find locus of loudness changes to be important was because of the difficulty in specifying a portion of the sound track to be either relevant or irrelevant. With deliberate planning, presumably variation in relevance could be more successfully achieved. A second possible extension would be to establish additional loudness levels in order to determine the form of the functional relation between amount of learning and such a variable as the magnitude of changes in loudness. A final suggestion is that the present procedures be employed with a more conventional film, _i_._e_., one that is shown in its entirety without interruption.

As for methodological steps that might be taken, one suggestion is that the loudness levels used in the present study be decreased in magnitude to preclude the possible aversion and distortion occasioned by the loudness level that was higher than normal. Another suggestion is that the material on the sound track be tape recorded anew. The original sound track, from which the tapes in the present study were made, was somewhat noisy as a result of prior use. Further, higher fidelity of sound is possible if the various tapes are made from a master tape than if they are made from the sound track built into the film.

As for suggestions based upon the present study that may be applied to the production of films, one such suggestion is that where emphasis of certain material is desired, the loudness level of the sound track be lowered momentarily. On the other hand, the results of the present study suggest that a constant low loudness level may be just as effective in promoting learning as the kind of changes just mentioned. Although good results occurred when the loudness level was constant and high, this level is not recommended because of the potential discomfort to the listener.

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APPENDIX

Appendix A

Student Response Sheet

Name ____________________

ANSWER SHEET

Direction: Mark the answer you choose by making a circle around the letter. Mark only one answer per item.

1. A B C D
2. A B C D
3. A B C D
4. A B C D

5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D
11. A B C D

12. A B C D
13. A B C D
14. A B C D
15. A B C D
16. A B C D
17. A B C D
18. A B C D

19. A B C D
20. A B C D
21. A B C D
22. A B C D
23. A B C D
24. A B C D
25. A B C D

26. A B C D
27. A B C D
28. A B C D
29. A B C D
30. A B C D

Appendix B

Instructions to Film Judges

Instructions to Film Judges

Initially judges were only told that they were part of a group judging the content of a film. After they completed the task, as outlined below, they were told the purpose of the experiment and thanked for their participation.

(JUDGES WERE BROUGHT INTO A ROOM, SEATED AT A DESK AND VIEWED THE FILM SHOWN OVER THEIR RIGHT SHOULDER ON A SCREEN 8 FT. AWAY WITH THE SOUND LEVEL "NORMAL.") I am going to show you a film called "Time." Its primary purpose is to show various ways by which man measures time. Included are sequences on the sundial, time zones, the international date line, daylight savings time, time measurement based on the stars and time/rate concepts and problems. The film was produced according to programmed instruction principles. At the end of each sequence, leader will show on the screen. Please view the film with an emphasis on how the concepts just mentioned are presented. (SHOW FILM.)

(PRESENT TEST AND SCRIPT.)

On your right is a copy of a test covering concepts presented in the film. On your left is the script of the film you just viewed. Your task is to underline portions of the script that directly aid the viewer to respond correctly to a test question. Please list in the left hand margin the corresponding test question number that applies to that particular section of the script. If you feel nothing in the script could aid a student in answering the test question, please indicate by a separate note on the cover sheet of the script. If you wish to see the film again or have any questions about your task, please indicate this to me now. I will not answer any questions once you begin to underline the script. (NONE OF THE JUDGES ASKED TO SEE THE FILM AGAIN. TWO JUDGES ASKED THE EXPERIMENTER TO ILLUSTRATE THE DESIRED METHOD OF UNDERLINING.)

Appendix C

Film Script with Relevant Portions Underlined

Film Script with Relevant Portions Underlined

THE EARTH, SPINNING AROUND IN THE SUN'S LIGHT, AGAIN AND AGAIN, LIKE THE HAND OF A CLOCK, SWEEPING ROUND AND ROUND. FOR CENTURIES MAN FOUND THIS ROTATION OF THE EARTH TO BE STEADIER, MORE REGULAR, MORE RELIABLE THAN ANYTHING HE HIMSELF COULD MAKE.

THE SUNDIAL WAS ONE EARLY TIME-KEEPING DEVICE THAT MADE USE OF THE EARTH'S ROTATION TO DETERMINE THE TIME OF DAY. THE SUNDIAL MARKS TIME BY CASTING A SHADOW WHICH CHANGES LENGTH AND DIRECTION AS THE EARTH ROTATES THRU THE SUN'S LIGHT.

BECAUSE THESE SUNDIALS ARE AT DIFFERENT POINTS IN THE SUNLIGHT, THEIR SHADOWS ARE DIFFERENT: AND, THEREFORE, WE SAY THEY TELL DIFFERENT TIMES. SUNDIALS MEASURE ONLY CHANGES IN SHADOWS. THEY DO NOT MEASURE EITHER THE HEAT OF THE SUN OR THE BRIGHTNESS OF THE SUN.

WHILE STUDENTS AT ONE LOCATION OF THE EARTH ARE IN SCHOOL...

STUDENTS AT ANOTHER LOCATION WILL JUST BE LEAVING FOR SCHOOL...

WHILE AT STILL ANOTHER LOCATION STUDENTS WILL STILL BE SLEEPING. SINCE EACH OF THESE STUDENTS IS AT A DIFFERENT POSITION IN RELATION TO THE SUN, EACH WILL HAVE A DIFFERENT POSITION IN RELATION TO THE SUN, EACH WILL HAVE A DIFFERENT SUN TIME OR LOCAL TIME.

BREAK

LOCAL TIME OR SUN TIME, SERVED PEOPLE VERY WELL BEFORE RAPID MEANS OF TRANSPORTATION WERE DEVELOPED. HOWEVER WITH THE BUILDING OF RAILROADS, PASSENGERS TRAVELING EAST OR WEST FOUND A DIFFERENT LOCAL TIME IN EACH TOWN ALONG THE WAY--

AND THE RAILROADS SOON HAD TO DEVELOP THEIR OWN SYSTEM OF TIME ZONES.

HOWEVER, AS THE PEOPLE SETTLED FARTHER FROM THE RAILROADS, A NEED GREW FOR DIVIDING THE WHOLE COUNTRY INTO ZONES OF STANDARD TIME.

BUT HOW SHOULD THE ZONES BE DETERMINED?

TO FIND THE ANSWER TO THIS PROBLEM LET'S TAKE A LONG LOOK DOWN ON THE EARTH FROM ABOVE THE NORTH POLE.

THE PATH OF THIS HOUSE AS IT ROTATES THROUGH ONE COMPLETE 24 HOUR DAY, IS A CIRCLE.

THIS CIRCLE CAN BE DIVIDED INTO 360 PARTS OR DEGREES. THEN WE CAN SAY THAT THE HOUSE ROTATES THROUGH 360 DEGREES IN ONE DAY OR 24 HOURS. NOW IF WE DIVIDE THE 360 DEGREE CIRCLE INTO 24 GROUPS OR PARTS, ONE PART FOR EACH HOUR OF THE DAY, THEN EACH OF THE PARTS WILL BE THE DISTANCE THE EARTH ROTATES THROUGH IN ONE HOUR. HOW MANY DEGREES WILL THERE BE IN EACH OF THESE PARTS? TO FIND THE ANSWERS, WE SIMPLY DIVIDE THE 360 DEGREES BY 24 PARTS. EACH PART WILL THEN BE...?

15 DEGREES.

THUS, TIME ZONES WITH ONE HOUR DIFFERENCE MAY BE MARKED OFF BY MERIDIANS 15 DEGREES APART...

AND THE ENTIRE EARTH CAN THEN BE DIVIDED INTO 24 OF THESE TIME ZONES.

THIS SYSTEM OF TIME ZONES DIVIDED THE ENTIRE UNITED STATES INTO FOUR ONE-HOUR ZONES, EASTERN, CENTRAL, MOUNTAIN, AND PACIFIC, THE TIME IN EACH ZONE BEING ONE HOUR AHEAD OF ITS NEIGHBOR TO THE WEST.

ON THE WEST COAST A STUDENT MAY STILL BE SLEEPING WHILE ON THE EAST COAST ANOTHER STUDENT IS JUST NOW IN THE MIDDLE OF HIS FIRST CLASS.

HOWEVER, THE ACTUAL ZONE BOUNDARIES DID NOT FOLLOW MERIDIAN LINES, BUT WERE BENT TO THE EAST OR WEST TO KEEP MAJOR CITIES AND THEIR TRADE CENTERS WITHIN THE SAME ZONE. OF COURSE, THESE BOUNDARIES ARE NOT ACTUALLY PAINTED ACROSS THE COUNTRY AS THEY ARE IN THIS PICTURE. THE INTRODUCTION OF THIS ONE HOUR TIME SYSTEM BROUGHT WITH IT A SERIOUS PROBLEM WHICH WE MUST NOW EXAMINE.

BREAK

WE ARE AGAIN LOOKING DOWN ON THE ROTATING EARTH FROM ABOVE THE NORTH POLE. WE WILL STOP THE ROTATION OF THE EARTH, OR IN OTHER WORDS, WE WILL FREEZE TIME IN ORDER TO SIMPLIFY OUR DISCUSSION OF THIS PROBLEM.

NOW, USING GREENWICH, ENGLAND, AS A STARTING POINT WE CAN DIVIDE THE EARTH INTO 24 ONE HOUR TIME ZONES.

LET US SAY IT IS 5 A.M. TUESDAY AT GREENWICH. THE NEXT ZONE HAS BEEN IN THE SUNLIGHT LONGER AND IS ONE HOUR LATER THAN GREENWICH TIME. LOCAL TIME IN EACH ZONE TO THE EAST IS ONE HOUR LATER.

HALFWAY AROUND THE WORLD, IT IS 5 P.M. TUESDAY...IN THIS ZONE IT IS MIDNIGHT, THE LAST HOUR OF TUESDAY. THE NEXT ZONE IS ONE HOUR LATER OR 1 A.M. WEDNESDAY THE BEGINNING OF A NEW DAY. THE NEXT ZONE IS 2 A.M. WEDNESDAY, 3 A.M. WEDNESDAY AND 4 A.M. WEDNESDAY AND RETURNING TO OUR STARTING

POINT WE SEE THE PROBLEM. ACCORDING TO THE COUNTING WE HAVE JUST DONE, WE SHOULD END UP AT 5 A.M. WEDNESDAY, BUT WHEN WE STARTED, WE SAID THIS ZONE WAS TO BE 5 A.M. TUESDAY. SINCE TIME WAS STOPPED FOR THIS PROBLEM, NOTHING COULD HAVE CHANGED AND SINCE IT CAN'T BE TWO DIFFERENT TIMES IN THE SAME ZONE IT IS CLEAR THAT WE WILL HAVE TO MAKE A CHANGE SOME PLACE. BUT WHERE?

LET US SAY THAT WHEN WE CROSS THIS LINE WE SUBTRACT ONE DAY FROM OUR CALENDAR. THE NEXT ZONE, INSTEAD OF BEING CALLED 6 P.M. TUESDAY WILL BE CALLED 6 P.M. MONDAY. WHEN WE CROSS THIS LINE WE WILL CHANGE ONLY THE CALENDAR DATE. FOR THIS REASON THIS LINE HAS COME TO BE CALLED THE INTERNATIONAL DATE LINE.

NOW THE NEXT ZONE WILL BE 7 P.M. MONDAY AND THE NEXT 8 P.M. MONDAY, 9 P.M., 10 P.M., 11 P.M., AND MIDNIGHT, THE LAST HOUR OF MONDAY. THE NEXT ZONE WILL THEN BE 1 A.M. TUESDAY, THE BEGINNING OF A NEW DAY, AND THE NEXT ZONE 2 A.M. TUESDAY, 3 A.M. TUESDAY, 4 A.M. TUESDAY, AND 5 A.M. TUESDAY. NOW IT COMES OUT CORRECTLY. HOW DID WE DO IT? IN CROSSING THE INTERNATIONAL DATE LINE WE SIMPLY CHANGED THE DATE ON OUR CALENDAR. WE DID NOT MAKE A CHANGE IN THE ONE HOUR TIME ZONE SYSTEM, BUT WE DID CHANGE THE DATE.

THIS INTERNATIONAL DATE LINE IS EXACTLY HALF WAY AROUND THE WORLD FROM GREENWICH, ENGLAND. THUS IN EACH ZONE TO THE EAST OF GREENWICH LOCAL TIME WILL BE AHEAD OF GREENWICH TIME...

IN FACT, LOCAL TIME IN ANY PARTICULAR ZONE TO THE EAST WILL BE FROM 1 TO 12 HOURS FASTER THAN GREENWICH TIME.

TO THE WEST OF GREENWICH, LOCAL TIME IN ANY PARTICULAR ZONE WILL BE 1 TO 12 HOURS SLOWER THAN GREENWICH TIME. SO, WE CAN SEE THAT LOCAL TIME IN ANY PARTICULAR ZONE WILL BE EITHER 1 TO 12 HOURS FASTER OR 1 TO 12 HOURS SLOWER THAN GREENWICH TIME, DEPENDING UPON HOW FAR EAST OR WEST OF GREENWICH THAT ZONE IS.

WITH THIS SYSTEM, A TRAVELER, MOVING IN AN EASTERLY DIRECTION, CAN ADD AN HOUR TO HIS CLOCK FOR EACH ZONE HE PASSES THROUGH, CONTINUE ADDING AN HOUR AS HE PASSES THE INTERNATIONAL DATE LINE, STILL MOVING IN AN EASTERLY DIRECTION, AND FINALLY COMPLETE HIS JOURNEY, HAVING ADDED 24 HOURS TO HIS CLOCK AND YET STILL NOT BE A DAY AHEAD OF THE PLACE HE STARTED FROM SIMPLY BECAUSE AT THE INTERNATIONAL DATE LINE HE SUBTRACTED ONE DAY OR 24 HOURS FROM HIS CALENDAR WHICH BALANCED OUT THE 24 HOURS HE ADDED TO HIS CLOCK ON HIS JOURNEY AROUND THE EARTH.

BREAK

SO FAR, WE HAVE SEEN HOW MAN DETERMINES THE LOCAL TIME IN HIS TOWN OR VILLAGE BY USING THE SHADOWS ON A SUNDIAL TO TELL HIM AT WHAT POINT IN THE CIRCLE OF THE EARTH'S ROTATION HIS PARTICULAR TOWN IS ROTATING THROUGH. NOW WE WILL SEE HOW SOME COMMUNITIES MAKE ANOTHER CHANGE IN THEIR TIME SYSTEM SO THAT THEY CAN TAKE ADVANTAGE OF THE GREATER NUMBER OF SUNLIGHT HOURS DURING THE SUMMER THAN IN THE WINTER.

IT IS A WARM SUMMER NIGHT AND THE PEOPLE IN THESE NEIGHBORING HOUSES ARE FAST ASLEEP. THIS PART OF THE EARTH IS ROTATING THROUGH DARKNESS.

BY 4 A.M., THESE HOUSES HAVE ROTATED AROUND TO A POSITION WHERE SOME OF THE SUN'S LIGHT CAN JUST BE SEEN IN THE SKY. IT IS DAWN.

BY 5 A.M., WE HAVE ROTATED INTO A POSITION WHERE WE CAN BEGIN TO SEE THE SUN ITSELF RISING IN THE EAST.

BY 6 A.M., EVEN THOUGH THESE HOUSES HAVE ALREADY BEEN ROTATING THROUGH THE SUNLIGHT FOR AN HOUR THE PEOPLE INSIDE ARE STILL SLEEPING. SINCE THEY WILL AWAKEN WHEN THEIR CLOCK READS 7 O'CLOCK, THEY WILL CONTINUE TO SLEEP THROUGH STILL ANOTHER HOUR OF SUNLIGHT. BUT THE PEOPLE IN ONE OF THESE HOUSES DECIDE THEY DON'T WANT TO BE ASLEEP WHILE THE SUN IS SHINING, SO ONE DAY THEY JUST MOVED THEIR CLOCK

AHEAD ONE HOUR. FOR THE REST OF THE SUMMER THEY WILL GET UP WHEN THE SUN IS ONLY THIS HIGH RATHER THAN WAITING AND SLEEPING THROUGH ANOTHER HOUR. THE PEOPLE IN THIS HOUSE HAVE CHANGED TO DAYLIGHT SAVING TIME BY MOVING THEIR CLOCK AHEAD ONE HOUR. NOW THEY WILL GET UP AT 7 A.M. AFTER HAVING SLEPT THROUGH ONLY ONE HOUR OF SUNLIGHT.

THE PEOPLE ON DAYLIGHT SAVING TIME WILL ALREADY BE LEAVING FOR SCHOOL OR WORK WHEN THE PEOPLE ON STANDARD TIME ARE JUST WAKING UP.

THE PEOPLE USING DAYLIGHT SAVING TIME WILL ALWAYS BE AN HOUR AHEAD OF THE PEOPLE USING STANDARD TIME EVEN THOUGH THE SUN IS AT THE SAME POINT IN THE SKY FOR BOTH.

BECAUSE THE PEOPLE ON DAYLIGHT SAVING TIME HAVE MOVED THEIR CLOCKS AHEAD AN HOUR, THE SUN SEEMS TO SET AN HOUR LATER, AT 8 P.M. RATHER THAN 7 P.M. AS IT DOES ON STANDARD TIME.

AND THE NEXT MORNING THE SUN WILL ALSO SEEM TO RISE AN HOUR LATER FOR THE DAYLIGHT SAVING TIME PEOPLE AT 6 A.M. RATHER THAN 5 A.M. WITH THE DAYLIGHT SAVING TIME SYSTEM, THEN, THE SUN SEEMS TO SET AN HOUR LATER, HOWEVER WHICHEVER SYSTEM YOU USE, IT WILL STILL TAKE 24 HOURS FOR THE EARTH TO ROTATE ON ITS AXIS BUT THE DAYLIGHT SAVING TIME PEOPLE WILL BE UP AND ABOUT THROUGH ONE DAYLIGHT HOUR WHILE THE STANDARD TIME PEOPLE ARE SLEEPING.

IN THE WINTER, THERE IS MUCH LESS SUNLIGHT EACH DAY. BOTH OF THESE HOUSES ARE NOW USING STANDARD TIME AND AT 5 A.M. THEY ARE BOTH IN DARKNESS.

AT 6 A.M., THEY ARE STILL IN DARKNESS. IF THE PEOPLE IN ONE OF THESE HOUSES CHANGED TO DAYLIGHT SAVING TIME BY MOVING THEIR CLOCKS AHEAD ONE HOUR, THEY WOULD ONLY BE GETTING UP WHILE IT WAS STILL DARK. THEY WOULD NOT HAVE ANY MORE SUNLIGHT HOURS TO USE THAN THE STANDARD TIME PEOPLE. SO BY USING DAYLIGHT SAVING TIME IN THE WINTER WE DO NOT GAIN OR LOSE ANY SUNLIGHT HOURS.

WE WILL USE THIS SPOTLIGHT AND THIS GLOBE TO REVIEW SOME OF THE IDEAS WE HAVE BEEN DISCUSSING. THE LIGHT WILL BE OUR SUN AND WILL STAY IN PLACE. THE EARTH, AS WE HAVE LEARNED, SHOULD ROTATE TO THE RIGHT OR EAST...

LIKE THIS.

NOTICE THAT SUNRISE IS HAPPENING ONLY FOR THOSE PARTS OF THE EARTH THAT ARE JUST ROTATING INTO THE SUN'S LIGHT AT THIS POINT.

NOON IS HAPPENING HERE WHERE THE EARTH IS IN THE MOST DIRECT SUNLIGHT.

MIDNIGHT IS HAPPENING HERE WHERE THIS PART OF THE EARTH IS FARTHEST FROM THE SUN.

WE CAN SEE HALF THE EARTH'S TOTAL ROTATION--THE A.M. HALF, EXTENDING FROM 12 MIDNIGHT TO 12 NOON.

AS EACH ZONE ON THE EARTH ROTATES INTO THE NEXT POSITION ITS STANDARD TIME CHANGES ACCORDINGLY. FOR EXAMPLE:

HERE ARE TWO HOUSES IN THE CENTRAL ZONE OF THE UNITED STATES. IT'S MIDNIGHT THERE.

NOW IT'S 1 A.M., 2 A.M., 3 A.M., 4 A.M., 5 A.M. WE SAY THE SUN HAS RISEN.

NOTICE THAT THESE HOUSES THAT ARE NORTH AND SOUTH OF EACH OTHER HAVE THE SAME---THEY ARE IN THE SAME ZONE.

HOWEVER, HOUSES TO THE EAST SHOULD HAVE A LATER TIME. THE SUN HAS ALREADY RISEN.

AND HOUSES TO THE WEST WOULD HAVE AN EARLIER TIME. IT IS BEFORE SUNRISE HERE.

FINALLY, WE MUST REMEMBER THAT TO CHANGE FROM STANDARD TIME TO DAYLIGHT SAVING TIME PEOPLE IN THESE HOUSES WILL SET THEIR CLOCKS AHEAD ONE HOUR.

BREAK

SO FAR WE HAVE SEEN BASING OUR DETERMINATION OF TIME ON THE SUN. BUT IS THIS METHOD SCIENTIFICALLY ACCURATE?

SEEN FROM THE EARTH, THE SUN'S POSITION AT HIGH NOON COULD LOOK LIKE THIS, THE SUN BEING DIRECTLY OVERHEAD.

BUT SCIENTISTS HAVE FOUND THAT SOMETIMES AT THE END OF PRECISELY 24 HOURS THE SUN HAS NOT QUITE RETURNED TO AN OVERHEAD POSITION AND SOMETIMES...

IT HAS GONE SLIGHTLY PAST THE OVERHEAD POSITION SO THAT A DAY MEASURED BY THE SUN'S POSITION WILL SOMETIMES BE SLIGHTLY LESS THAN 24 HOURS AND SOMETIMES SLIGHTLY MORE. TO MAKE MORE ACCURATE TIME DETERMINATIONS FROM THE SUN'S POSITION, ASTRONOMERS...

USE THE AVERAGE MOTION OF THE SUN OR THE MEAN SUN. HOWEVER, THEY HAVE FOUND THAT THEY CAN MAKE STILL MORE ACCURATE TIME DETERMINATIONS...

BY OBSERVING THE PATHS OF STARS AS THEY PASS DIRECTLY OVERHEAD.

IN THE UNITED STATES, ASTRONOMERS AT THE NAVAL OBSERVATORY IN WASHINGTON, D.C., MAKE OBSERVATIONS OF THE STARS EACH CLEAR NIGHT. AS CERTAIN STARS PASS DIRECTLY OVERHEAD...

THEY ARE PHOTOGRAPHED BY A SPECIAL INSTRUMENT. FROM THESE SPECIAL PHOTOGRAPHS THE ASTRONOMER CAN MAKE A MORE EXACT MEASUREMENT OF THE EARTH'S ROTATION AND IF NECESSARY, CORRECT A SPECIAL CLOCK. TIME SIGNALS BASED ON THIS SPECIAL CLOCK ARE BROADCAST ALL OVER THE WORLD...

BY RADIO STATION WWV LOCATED NEAR WASHINGTON, D.C. THIS STATION IS OPERATED BY THE NATIONAL BUREAU OF STANDARDS. ITS TIME SIGNALS ARE ACCURATE AND OFFICIAL SINCE THEY ARE BASED ON THE SPECIAL CLOCK, CORRECTED ACCORDING TO THE OBSERVATIONS OF THE STARS.

THESE TIME SIGNALS FROM WWV, WHICH ARE VERY ACCURATE AND OFFICIAL, CAN BE PICKED UP ONLY BY SHORT WAVE RADIOS.

TIME SIGNALS FROM LOCAL RADIO STATIONS WHICH ARE GENERALLY ACCURATE BUT NOT OFFICIAL CAN BE PICKED UP BY ORDINARY HOME RADIOS.

REMEMBER THEN THAT THE CORRECT TIME IS DETERMINED AT THE UNITED STATES NAVAL OBSERVATORY BY ASTRONOMERS, BUT BROADCAST ALL OVER THE WORLD BY RADIO STATIONS OPERATED BY THE NATIONAL BUREAU OF STANDARDS.

Appendix D

Film Script with Irrelevant Portions Underlined Approximating Length of Relevant Portions

Film Script with Irrelevant Portions Underlined
Approximating Length of Relevant Portions

THE EARTH, SPINNING AROUND IN THE SUN'S LIGHT, AGAIN AND AGAIN, LIKE THE HAND OF A CLOCK, SWEEPING ROUND AND ROUND. FOR CENTURIES MAN FOUND THIS ROTATION OF THE EARTH TO BE STEADIER, MORE REGULAR, MORE RELIABLE THAN ANYTHING HE HIMSELF COULD MAKE.

THE SUNDIAL WAS ONE EARLY TIME-KEEPING DEVICE THAT MADE USE OF THE EARTH'S ROTATION TO DETERMINE THE TIME OF DAY. THE SUNDIAL MARKS TIME BY CASTING A SHADOW WHICH CHANGES LENGTH AND DIRECTION AS THE EARTH ROTATES THRU THE SUN'S LIGHT.

BECAUSE THESE SUNDIALS ARE AT DIFFERENT POINTS IN THE SUNLIGHT, THEIR SHADOWS ARE DIFFERENT: AND, THEREFORE, WE SAY THEY TELL DIFFERENT TIMES. SUNDIALS MEASURE ONLY CHANGES IN SHADOWS. THEY DO NOT MEASURE EITHER THE HEAT OF THE SUN OR THE BRIGHTNESS OF THE SUN.

WHILE STUDENTS AT ONE LOCATION OF THE EARTH ARE IN SCHOOL...

STUDENTS AT ANOTHER LOCATION WILL JUST BE LEAVING FOR SCHOOL...

WHILE AT STILL ANOTHER LOCATION STUDENTS WILL STILL BE SLEEPING. SINCE EACH OF THESE STUDENTS IS AT A DIFFERENT POSITION IN RELATION TO THE SUN, EACH WILL HAVE A DIFFERENT POSITION IN RELATION TO THE SUN, EACH WILL HAVE A DIFFERENT SUN TIME OR LOCAL TIME.

BREAK

LOCAL TIME OR SUN TIME, SERVED PEOPLE VERY WELL BEFORE RAPID MEANS OF TRANSPORTATION WERE DEVELOPED. HOWEVER WITH THE BUILDING OF RAILROADS, PASSENGERS TRAVELING EAST OR WEST FOUND A DIFFERENT LOCAL TIME IN EACH TOWN ALONG THE WAY--

AND THE RAILROADS SOON HAD TO DEVELOP THEIR OWN SYSTEM OF TIME ZONES.

HOWEVER, AS THE PEOPLE SETTLED FARTHER FROM THE RAILROADS, A NEED GREW FOR DIVIDING THE WHOLE COUNTRY INTO ZONES OF STANDARD TIME.

BUT HOW SHOULD THE ZONES BE DETERMINED?

TO FIND THE ANSWER TO THIS PROBLEM LET'S TAKE A LONG LOOK DOWN ON THE EARTH FROM ABOVE THE NORTH POLE.

THE PATH OF THIS HOUSE AS IT ROTATES THROUGH ONE COMPLETE 24 HOUR DAY, IS A CIRCLE.

THIS CIRCLE CAN BE DIVIDED INTO 360 PARTS OR DEGREES. THEN WE CAN SAY THAT THE HOUSE ROTATES THROUGH 360 DEGREES IN ONE DAY OR 24 HOURS. NOW IF WE DIVIDE THE 360 DEGREE CIRCLE INTO 24 GROUPS OR PARTS, ONE PART FOR EACH HOUR OF THE DAY, THEN EACH OF THE PARTS WILL BE THE DISTANCE THE EARTH ROTATES THROUGH IN ONE HOUR. HOW MANY DEGREES WILL THERE BE IN EACH OF THESE PARTS? TO FIND THE ANSWERS, WE SIMPLY DIVIDE THE 360 DEGREES BY 24 PARTS. EACH PART WILL THEN BE...?

15 DEGREES.

THUS, TIME ZONES WITH ONE HOUR DIFFERENCE MAY BE MARKED OFF BY MERIDIANS 15 DEGREES APART...

AND THE ENTIRE EARTH CAN THEN BE DIVIDED INTO 24 OF THESE TIME ZONES.

THIS SYSTEM OF TIME ZONES DIVIDED THE ENTIRE UNITED STATES INTO FOUR ONE-HOUR ZONES, EASTERN, CENTRAL, MOUNTAIN, AND PACIFIC, THE TIME IN EACH ZONE BEING ONE HOUR AHEAD OF ITS NEIGHBOR TO THE WEST.

ON THE WEST COAST A STUDENT MAY STILL BE SLEEPING WHILE ON THE EAST COAST ANOTHER STUDENT IS JUST NOW IN THE MIDDLE OF HIS FIRST CLASS.

HOWEVER, THE ACTUAL ZONE BOUNDARIES DID NOT FOLLOW MERIDIAN LINES, BUT WERE BENT TO THE EAST OR WEST TO KEEP MAJOR CITIES AND THEIR TRADE CENTERS WITHIN THE SAME ZONE. OF COURSE, THESE BOUNDARIES ARE NOT ACTUALLY PAINTED ACROSS THE COUNTRY AS THEY ARE IN THIS PICTURE. THE INTRODUCTION OF THIS ONE HOUR TIME SYSTEM BROUGHT WITH IT A SERIOUS PROBLEM WHICH WE MUST NOW EXAMINE.

BREAK

WE ARE AGAIN LOOKING DOWN ON THE ROTATING EARTH FROM ABOVE THE NORTH POLE. WE WILL STOP THE ROTATION OF THE EARTH, OR IN OTHER WORDS, WE WILL FREEZE TIME IN ORDER TO SIMPLIFY OUR DISCUSSION OF THIS PROBLEM.

NOW, USING GREENWICH, ENGLAND, AS A STARTING POINT WE CAN DIVIDE THE EARTH INTO 24 ONE HOUR TIME ZONES.

LET US SAY IT IS 5 A.M. TUESDAY AT GREENWICH. THE NEXT ZONE HAS BEEN IN THE SUNLIGHT LONGER AND IS ONE HOUR LATER THAN GREENWICH TIME. LOCAL TIME IN EACH ZONE TO THE EAST IS ONE HOUR LATER.

HALFWAY AROUND THE WORLD, IT IS 5 P.M. TUESDAY...IN THIS ZONE IT IS MIDNIGHT, THE LAST HOUR OF TUESDAY. THE NEXT ZONE IS ONE HOUR LATER OR 1 A.M. WEDNESDAY THE BEGINNING OF A NEW DAY. THE NEXT ZONE IS 2 A.M. WEDNESDAY, 3 A.M. WEDNESDAY AND 4 A.M. WEDNESDAY AND RETURNING TO OUR STARTING

POINT WE SEE THE PROBLEM. ACCORDING TO THE COUNTING WE HAVE JUST DONE, WE SHOULD END UP AT 5 A.M. WEDNESDAY, BUT WHEN WE STARTED, WE SAID THIS ZONE WAS TO BE 5 A.M. TUESDAY. SINCE TIME WAS STOPPED FOR THIS PROBLEM, NOTHING COULD HAVE CHANGED AND SINCE IT CAN'T BE TWO DIFFERENT TIMES IN THE SAME ZONE IT IS CLEAR THAT WE WILL HAVE TO MAKE A CHANGE SOME PLACE. BUT WHERE?

LET US SAY THAT WHEN WE CROSS THIS LINE WE SUBTRACT ONE DAY FROM OUR CALENDAR. THE NEXT ZONE, INSTEAD OF BEING CALLED 6 P.M. TUESDAY WILL BE CALLED 6 P.M. MONDAY. WHEN WE CROSS THIS LINE WE WILL CHANGE ONLY THE CALENDAR DATE. FOR THIS REASON THIS LINE HAS COME TO BE CALLED THE INTERNATIONAL DATE LINE.

NOW THE NEXT ZONE WILL BE 7 P.M. MONDAY AND THE NEXT 8 P.M. MONDAY, 9 P.M., 10 P.M., 11 P.M., AND MIDNIGHT, THE LAST HOUR OF MONDAY. THE NEXT ZONE WILL THEN BE 1 A.M., TUESDAY, THE BEGINNING OF A NEW DAY, AND THE NEXT ZONE 2 A.M. TUESDAY, 3 A.M. TUESDAY, 4 A.M. TUESDAY, AND 5 A.M. TUESDAY. NOW IT COMES OUT CORRECTLY. HOW DID WE DO IT? IN CROSSING THE INTERNATIONAL DATE LINE WE SIMPLY CHANGED THE DATE ON OUR CALENDAR. WE DID NOT MAKE A CHANGE IN THE ONE HOUR TIME ZONE SYSTEM, BUT WE DID CHANGE THE DATE.

THIS INTERNATIONAL DATE LINE IS EXACTLY HALF WAY AROUND THE WORLD FROM GREENWICH, ENGLAND. THUS IN EACH ZONE TO THE EAST OF GREENWICH LOCAL TIME WILL BE AHEAD OF GREENWICH TIME...

IN FACT, LOCAL TIME IN ANY PARTICULAR ZONE TO THE EAST WILL BE FROM 1 TO 12 HOURS FASTER THAN GREENWICH TIME.

TO THE WEST OF GREENWICH, LOCAL TIME IN ANY PARTICULAR ZONE WILL BE 1 TO 12 HOURS SLOWER THAN GREENWICH TIME. SO, WE CAN SEE THAT LOCAL TIME IN ANY PARTICULAR ZONE WILL BE EITHER 1 TO 12 HOURS FASTER OR 1 TO 12 HOURS SLOWER THAN GREENWICH TIME, DEPENDING UPON HOW FAR EAST OR WEST OF GREENWICH THAT ZONE IS.

WITH THIS SYSTEM, A TRAVELER, MOVING IN AN EASTERLY DIRECTION, CAN ADD AN HOUR TO HIS CLOCK FOR EACH ZONE HE PASSES THROUGH, CONTINUE ADDING AN HOUR AS HE PASSES THE INTERNATIONAL DATE LINE, STILL MOVING IN AN EASTERLY DIRECTION, AND FINALLY COMPLETE HIS JOURNEY, HAVING ADDED 24 HOURS TO HIS CLOCK AND YET STILL NOT BE A DAY AHEAD OF THE PLACE HE STARTED FROM SIMPLY BECAUSE AT THE INTERNATIONAL DATE LINE HE SUBTRACTED ONE DAY OR 24 HOURS FROM HIS CALENDAR WHICH BALANCED OUT THE 24 HOURS HE ADDED TO HIS CLOCK ON HIS JOURNEY AROUND THE EARTH.

BREAK

SO FAR, WE HAVE SEEN HOW MAN DETERMINES THE LOCAL TIME IN HIS TOWN OR VILLAGE BY USING THE SHADOWS ON A SUNDIAL TO TELL HIM AT WHAT POINT IN THE CIRCLE OF THE EARTH'S ROTATION HIS PARTICULAR TOWN IS ROTATING THROUGH. NOW WE WILL SEE HOW SOME COMMUNITIES MAKE ANOTHER CHANGE IN THEIR TIME SYSTEM SO THAT THEY CAN TAKE ADVANTAGE OF THE GREATER NUMBER OF SUNLIGHT HOURS DURING THE SUMMER THAN IN THE WINTER.

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BY 4 A.M., THESE HOUSES HAVE ROTATED AROUND TO A POSITION WHERE SOME OF THE SUN'S LIGHT CAN JUST BE SEEN IN THE SKY. IT IS DAWN.

BY 5 A.M., WE HAVE ROTATED INTO A POSITION WHERE WE CAN BEGIN TO SEE THE SUN ITSELF RISING IN THE EAST.

BY 6 A.M., EVEN THOUGH THESE HOUSES HAVE ALREADY BEEN ROTATING THROUGH THE SUNLIGHT FOR AN HOUR THE PEOPLE INSIDE ARE STILL SLEEPING. SINCE THEY WILL AWAKEN WHEN THEIR CLOCK READS 7 O'CLOCK, THEY WILL CONTINUE TO SLEEP THROUGH STILL ANOTHER HOUR OF SUNLIGHT. BUT THE PEOPLE IN ONE OF THESE HOUSES DECIDE THEY DON'T WANT TO BE ASLEEP WHILE THE SUN IS SHINING, SO ONE DAY THEY JUST MOVED THEIR CLOCK

AHEAD ONE HOUR. FOR THE REST OF THE SUMMER THEY WILL GET UP WHEN THE SUN IS ONLY THIS HIGH RATHER THAN WAITING AND SLEEPING THROUGH ANOTHER HOUR. THE PEOPLE IN THIS HOUSE HAVE CHANGED TO DAYLIGHT SAVING TIME BY MOVING THEIR CLOCK AHEAD ONE HOUR. NOW THEY WILL GET UP AT 7 A.M. AFTER HAVING SLEPT THROUGH ONLY ONE HOUR OF SUNLIGHT.

THE PEOPLE ON DAYLIGHT SAVING TIME WILL ALREADY BE LEAVING FOR SCHOOL OR WORK WHEN THE PEOPLE ON STANDARD TIME ARE JUST WAKING UP.

THE PEOPLE USING DAYLIGHT SAVING TIME WILL ALWAYS BE AN HOUR AHEAD OF THE PEOPLE USING STANDING TIME EVEN THOUGH THE SUN IS AT THE SAME POINT IN THE SKY FOR BOTH.

BECAUSE THE PEOPLE ON DAYLIGHT SAVING TIME HAVE MOVED THEIR CLOCKS AHEAD AN HOUR, THE SUN SEEMS TO SET AN HOUR LATER, AT 8 P.M. RATHER THAN 7 P.M. AS IT DOES ON STANDARD TIME.

AND THE NEXT MORNING THE SUN WILL ALSO SEEM TO RISE AN HOUR LATER FOR THE DAYLIGHT SAVING TIME PEOPLE AT 6 A.M. RATHER THAN 5 A.M. WITH THE DAYLIGHT SAVING TIME SYSTEM, THEN, THE SUN SEEMS TO SET AN HOUR LATER, HOWEVER WHICHEVER SYSTEM YOU USE, IT WILL STILL TAKE 24 HOURS FOR THE EARTH TO ROTATE ON ITS AXIS BUT THE DAYLIGHT SAVING TIME PEOPLE WILL BE UP AND ABOUT THROUGH ONE DAYLIGHT HOUR WHILE THE STANDARD TIME PEOPLE ARE SLEEPING.

IN THE WINTER, THERE IS MUCH LESS SUNLIGHT EACH DAY. BOTH OF THESE HOUSES ARE NOW USING STANDARD TIME AND AT 5 A.M. THEY ARE BOTH IN DARKNESS.

AT 6 A.M., THEY ARE STILL IN DARKNESS. IF THE PEOPLE IN ONE OF THESE HOUSES CHANGED TO DAYLIGHT SAVING TIME BY MOVING THEIR CLOCKS AHEAD ONE HOUR, THEY WOULD ONLY BE GETTING UP WHILE IT WAS STILL DARK. THEY WOULD NOT HAVE ANY MORE SUNLIGHT HOURS TO USE THAN THE STANDARD TIME PEOPLE. SO BY USING DAYLIGHT SAVING TIME IN THE WINTER WE DO NOT GAIN OR LOSE ANY SUNLIGHT HOURS.

WE WILL USE THIS SPOTLIGHT AND THIS GLOBE TO REVIEW SOME OF THE IDEAS WE HAVE BEEN DISCUSSING. THE LIGHT WILL BE OUR SUN AND WILL STAY IN PLACE. THE EARTH, AS WE HAVE LEARNED, SHOULD ROTATE TO THE RIGHT OR EAST...

LIKE THIS.

NOTICE THAT SUNRISE IS HAPPENING ONLY FOR THOSE PARTS OF THE EARTH THAT ARE JUST ROTATING INTO THE SUN'S LIGHT AT THIS POINT.

NOON IS HAPPENING HERE WHERE THE EARTH IS IN THE MOST DIRECT SUNLIGHT.

MIDNIGHT IS HAPPENING HERE WHERE THIS PART OF THE EARTH IS FARTHEST FROM THE SUN.

WE CAN SEE HALF THE EARTH'S TOTAL ROTATION--THE A.M. HALF, EXTENDING FROM 12 MIDNIGHT TO 12 NOON.

AS EACH ZONE ON THE EARTH ROTATES INTO THE NEXT POSITION ITS STANDARD TIME CHANGES ACCORDINGLY. FOR EXAMPLE:

HERE ARE TWO HOUSES IN THE CENTRAL ZONE OF THE UNITED STATES. IT'S MIDNIGHT THERE.

NOW IT'S 1 A.M., 2 A.M., 3 A.M., 4 A.M., 5 A.M. WE SAY THE SUN HAS RISEN.

NOTICE THAT THESE HOUSES THAT ARE NORTH AND SOUTH OF EACH OTHER HAVE THE SAME---THEY ARE IN THE SAME ZONE.

HOWEVER, HOUSES TO THE EAST SHOULD HAVE A LATER TIME. THE SUN HAS ALREADY RISEN.

AND HOUSES TO THE WEST WOULD HAVE AN EARLIER TIME. IT IS BEFORE SUNRISE HERE.

FINALLY, WE MUST REMEMBER THAT TO CHANGE FROM STANDARD TIME TO DAYLIGHT SAVING TIME PEOPLE IN THESE HOUSES WILL SET THEIR CLOCKS AHEAD ONE HOUR.

BREAK

SO FAR WE HAVE SEEN BASING OUR DETERMINATION OF TIME ON THE SUN. BUT IS THIS METHOD SCIENTIFICALLY ACCURATE?

SEEN FROM THE EARTH, THE SUN'S POSITION AT HIGH NOON COULD LOOK LIKE THIS, THE SUN BEING DIRECTLY OVERHEAD.

BUT SCIENTISTS HAVE FOUND THAT SOMETIMES AT THE END OF PRECISELY 24 HOURS THE SUN HAS NOT QUITE RETURNED TO AN OVERHEAD POSITION AND SOMETIMES...

IT HAS GONE SLIGHTLY PAST THE OVERHEAD POSITION SO THAT A DAY MEASURED BY THE SUN'S POSITION WILL SOMETIMES BE SLIGHTLY LESS THAN 24 HOURS AND SOMETIMES SLIGHTLY MORE. TO MAKE MORE ACCURATE TIME DETERMINATIONS FROM THE SUN'S POSITION, ASTRONOMERS...

USE THE AVERAGE MOTION OF THE SUN OR THE MEAN SUN. HOWEVER, THEY HAVE FOUND THAT THEY CAN MAKE STILL MORE ACCURATE TIME DETERMINATIONS...

BY OBSERVING THE PATHS OF STARS AS THEY PASS DIRECTLY OVERHEAD.

IN THE UNITED STATES, ASTRONOMERS AT THE NAVAL OBSERVATORY IN WASHINGTON, D.C., MAKE OBSERVATIONS OF THE STARS EACH CLEAR NIGHT. AS CERTAIN STARS PASS DIRECTLY OVERHEAD...

THEY ARE PHOTOGRAPHED BY A SPECIAL INSTRUMENT. FROM THESE SPECIAL PHOTOGRAPHS THE ASTRONOMER CAN MAKE A MORE EXACT MEASUREMENT OF THE EARTH'S ROTATION AND IF NECESSARY, CORRECT A SPECIAL CLOCK. TIME SIGNALS BASED ON THIS SPECIAL CLOCK ARE BROADCAST ALL OVER THE WORLD...

BY RADIO STATION WWV LOCATED NEAR WASHINGTON, D.C. THIS STATION IS OPERATED BY THE NATIONAL BUREAU OF STANDARDS. ITS TIME SIGNALS ARE ACCURATE AND OFFICIAL SINCE THEY ARE BASED ON THE SPECIAL CLOCK, CORRECTED ACCORDING TO THE OBSERVATIONS OF THE STARS.

THESE TIME SIGNALS FROM WWV, WHICH ARE VERY ACCURATE AND OFFICIAL, CAN BE PICKED UP ONLY BY SHORT WAVE RADIOS.

TIME SIGNALS FROM LOCAL RADIO STATIONS WHICH ARE GENERALLY ACCURATE BUT NOT OFFICIAL CAN BE PICKED UP BY ORDINARY HOME RADIOS.

REMEMBER THEN THAT THE CORRECT TIME IS DETERMINED AT THE UNITED STATES NAVAL OBSERVATORY BY ASTRONOMERS, BUT BROADCAST ALL OVER THE WORLD BY RADIO STATIONS OPERATED BY THE NATIONAL BUREAU OF STANDARDS.

Appendix E

Instructions to Subjects

Instructions to Subjects

(STUDENTS ENTERED THE MULTI-PURPOSE ROOM AND WERE ADVISED TO TAKE ANY SEAT THEY WISHED. AFTER ALL STUDENTS WERE SEATED THE EXPERIMENTER READ THE FOLLOWING INSTRUCTIONS.)

Good morning (afternoon for one group), boys and girls. Please make yourself comfortable and adjust yourselves so you will be able to see the screen. Please do not touch anything on the table in front of you until I tell you to do so.

You are going to see a film this morning (afternoon) called "Time." During the showing of the film we will stop at certain times and ask you questions about the film. Those questions are in the green book in front of you. Please open this book to the first page. You should take the pencil and write your name in the upper right hand corner of the answer sheet.

Look at the first page. This is a sample of what the questions will be like. All the questions will be multiple-choice. When you answer a question, match the question number from the test and the letter in front of the answer you choose with the question and the letter number on the answer sheet, then circle the correct letter on the answer sheet. Any questions? (SOME STUDENTS ASKED WHAT THE PURPOSE OF THE EXPERIMENT WAS, AND WERE TOLD THAT THIS WOULD BE EXPLAINED LATER DUE TO THE PRESS OF TIME.)

So you won't be disturbed by any noise from the playground we will all wear headsets. Look at me and I will show you how to wear them. (EXPERIMENTER PUT ON A HEADSET AND ILLUSTRATED HOW THEY WERE TO BE WORN. ASSISTANT AND EXPERIMENTER HELPED VARIOUS STUDENTS MAKE PROPER ADJUSTMENTS.) Look at the screen; the film is going to start.

(FILM SHOWN. AT THE END OF THE FIRST SECTION THE FILM PROJECTOR WAS TURNED OFF.)

Please turn the page to question one. Answer the questions until you come to the page that tells you to stop.

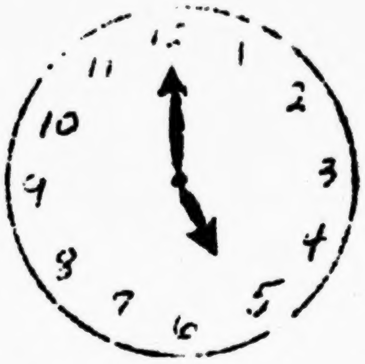
(THIS PROCEUDRE WAS REPEATED FOR ALL BREAKS IN THE FILM. AT THE CONCLUSION OF THE FILM SHOWING, STUDENTS WERE ASKED TO PASS IN THEIR ANSWER SHEETS.)

Thank you for your cooperation. Since we are just about out of time I will ask your home room teachers to explain why you were here today. I will ask you on your honor not to talk about the film and the test with anyone else, including teachers, until Friday noon. You may now go back to your regular classes. Thank you.

Appendix F

Film Test

50.



According to this clock the time is
A. 2 o'clock.
B. 3 o'clock.
C. 11 o'clock.
D. 5 o'clock.

Mark your choice in the correct place on the answer sheet.

51. The name of the day that comes after Monday and before Wednesday is
A. Thursday.
B. Tuesday.
C. Sunday.
D. There is no such day.

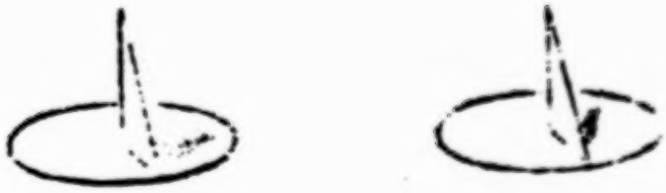
Mark your choice on the answer sheet. Wait for further instructions.

1. Time can be determined from the sun because
   - A. the sun shines hotter at different times of day.
   - B. the sun is at different positions in the sky at different times of day.
   - C. the sun moves back and forth like a pendulum clock.
   - D. both A and B are correct.

Mark your choice on the answer sheet. Then turn this page.

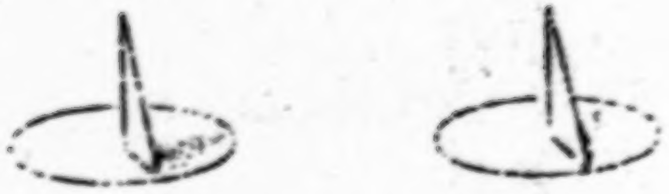
2. Sundials to the east or west of each other, such as a sundial on the East Coast and one on the West Coast, tell different times, because
   - A. they are set to work at different rates.
   - B. they are at different sea levels.
   - C. the parts of the earth they are on rotate or spin into the sun's light at different times.
   - D. the parts of the earth they are on revolve or move around the sun at different rates.

Mark your choice on the answer sheet. Then turn this page.



3. If the above shadows were cast at exactly the same instant, it could be explained by saying that the
   A. sundials were poorly built.
   B. sun was shining more brightly where the first shadow was cast and therefore the first shadow was larger.
   C. shadows were cast by two different sundials, many miles to the North and South of each other.
   D. shadows were cast by two different sundials, many miles to the East and West of each other.

Mark your choice on the answer sheet. Then turn this page.



4. If the same sundial cast both these shadows, it could probably be explained by saying
   - A. the shadows were cast at different times during a single day.
   - B. the sundial was built poorly.
   - C. the sun was shining more brightly when the first shadow was cast, therefore the first shadow was larger.
   - D. any of the above reasons are correct.

Mark your choice on the answer sheet. Then turn this page.

STOP!

DO NOT turn to next page yet.

WAIT till you have seen the next part of the film.

5. To determine the part of a circle through which the earth rotates in one hour
   - A. multiply 360 degrees by 24 hours.
   - B. add 360 degrees and 24 hours.
   - C. divide 360 degrees by one hour.
   - D. divide 360 degrees by 24 hours.

Mark your choice on the answer sheet. Then turn this page.

[illegible]. If a point on the earth's surface took 36 hours to rotate through a full circle, how many hours would there be in one day?

A. 12 hours.
B. 24 hours.
C. 36 hours.
D. can't tell from the information given.

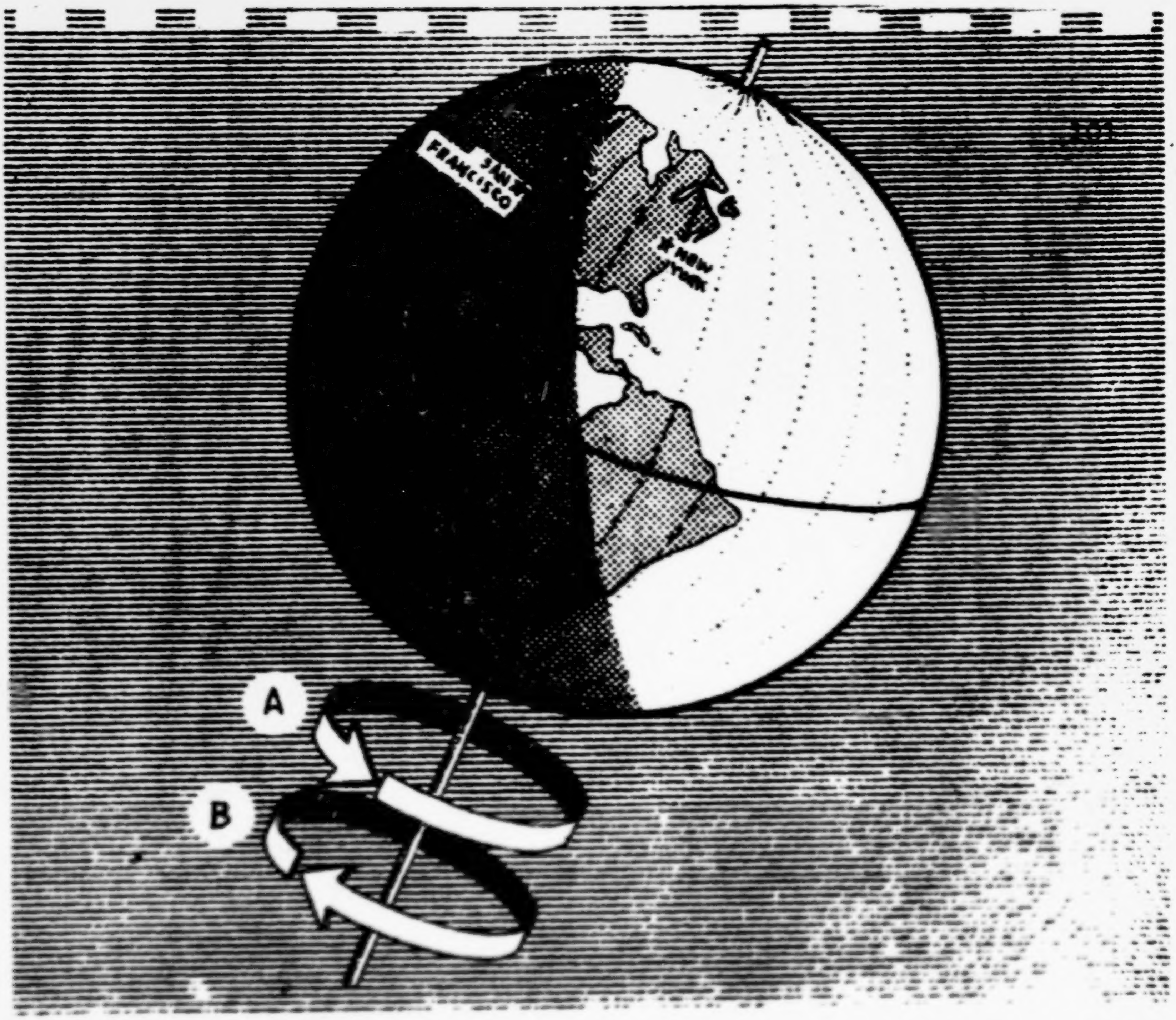
Mark your choice on the answer sheet. Then turn this page.

7. Standard time zones were developed because rapidly moving travelers found that
   A. small towns all had the same time as Greenwich, England.
   B. sun time was different in towns north and south of each other.
   C. sun time could not be determined from a rapidly moving train.
   D. sun time was different in towns to the east or west of other towns.

Mark your choice on the answer sheet. Then turn this page.

8. Planet X, the same size as the earth, rotates through 360 degrees in 12 hours. If a standard one-hour time zone system, like the one on earth, was developed for Planet X, time zones would be
    A. the same size as the earth's.
    B. larger than the earth's.
    C. smaller than the earth's.
    D. of any size that the people on Planet X wished to make them.

Mark your choice on the answer sheet. Then turn this page.



9. Knowing that the sun rises in the east and sets in the west, we can say that
   - a. the earth rotates in the direction of Arrow A.
   - b. the earth rotates in the direction of Arrow B.
   - c. the earth rotates in the direction of Arrow A during the day and in the direction of Arrow B during the night.
   - d. we don't have enough information to make a statement about the earth's rotation.

10. If the earth were to rotate in the direction of Arrow A, then the next day
    - a. the sun would rise in San Francisco before it would rise in New York.
    - b. the sun would rise in New York before it would rise in San Francisco.
    - c. the sun would rise in New York and San Francisco at the same time.
    - d. we wouldn't have enough information to say whether the sun would rise first in New York or first in San Francisco.

11. If it is 8:00 a.m. in New York in picture above, which of the following times might it be in San Francisco?
    - a. 5:00 a.m.
    - b. 11:00 a.m.
    - c. 10:00 a.m.
    - d. 2:00 p.m.

Mark your choice on the answer sheet. Then turn this page.

STOP!

DO NOT turn to next page yet.

WAIT till you have seen the next part of the film.

12. Most time systems are based on 15 degree meridians counted from
    - A. Washington, D. C.
    - B. New York.
    - C. Greenwich, England.
    - D. London, England.

Mark your choice on the answer sheet. Then turn this page.

13. Local time in each time zone
    A. is one to 12 hours faster than Greenwich time.
    B. is one to 12 hours slower than Greenwich time.
    C. could be either 12 hours faster or slower than Greenwich time.
    D. could not be different from Greenwich time.

Mark your choice on the answer sheet. Then turn this page.

14. A traveler passing from one zone to the next one to the East, must
    - A. add an hour.
    - B. subtract an hour.
    - C. either add or subtract an hour.
    - D. not change his clock.

Mark your choice on the answer sheet. Then turn this page.

15. If a traveler added an hour for every zone he passed through on his eastward journey, how many hours would he have to add for a complete journey around the earth?
    - A. twelve hours.
    - B. 36 hours.
    - C. It would depend on which countries he passed through.
    - D. none of the above.

Mark your choice on the answer sheet. Then turn this page.

16. If it were not for the International Dateline, east or west bound travelers who made a complete journey around the earth would arrive back at their starting point with
    - A. their clock 12 hours ahead of its starting point.
    - B. their clock 12 hours behind its starting point.
    - C. their calendhr the same as when they started.
    - D. their calendar a day later or earlier than when they started.

Mark your choice on the answer sheet. Then turn this page.

17. A traveler crossing the International Dateline will, depending upon the direction he's traveling, either
    - A. add or subtract one hour on his clock.
    - B. add or subtract a day on his calendar.
    - C. add or subtract 12 hours on his clock.
    - D. none of the above.

Mark your choice on the answer sheet. Then turn this page.

16. If a traveler *subtracts* an hour for each zone as he travels west what kind of change must he make as he crosses the International Dateline?
    - A. subtract 24 hours.
    - B. add 24 hours.
    - C. add 12 hours.
    - D. add the number of hours he has already subtracted.

Mark your choice on the answer sheet. Then turn this page.

STOP!

DO NOT turn to next page yet.

WAIT till you have seen the next part of the film.

19. When we change from Standard Time to Daylight Saving Time in the spring we should set our clock
    - A. one hour ahead of our regular time.
    - B. two hours ahead of our regular time.
    - C. one hour behind the regular time.
    - D. two hours behind the regular time.

Mark your choice on the answer sheet. Then turn this page.

20. When we set the clock ahead an hour in the Daylight Saving Time system the sun seems to

   A. rise and set an hour later.
   B. rise and set an hour earlier.
   C. rise an hour later and set an hour earlier.
   D. rise an hour earlier and set an hour later.

Mark your choice on the answer sheet. Then turn this page.

21. In the winter, by using Daylight Saving Time instead of Standard Time we
    A. gain an hour of daylight.
    B. lose an hour of daylight.
    C. do not lose or gain an hour of daylight.
    D. stay awake longer each day.

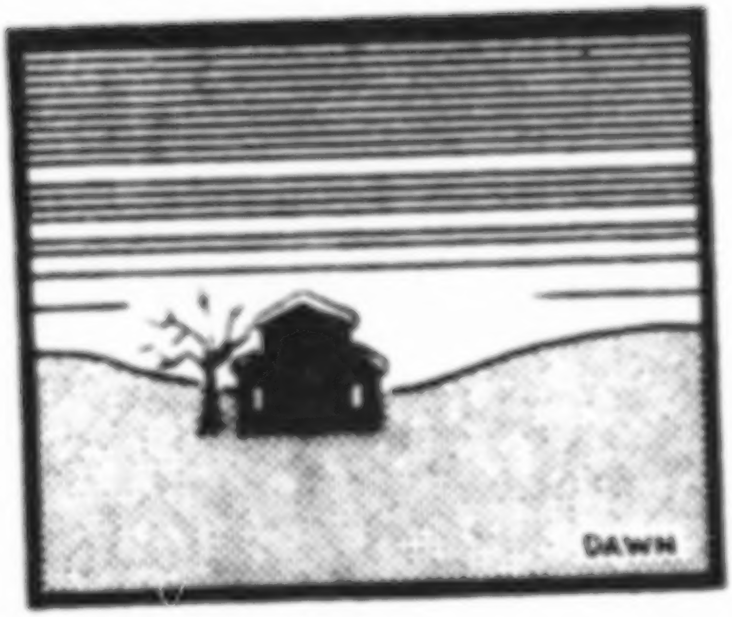
Mark your choice on the answer sheet. Then turn this page.

22. The people in Mudville, who use the Standard Time system, put on their favorite television program when their clock points to 8:00 p.m.

The people in the neighboring city of Watertown, (in the same time zone as Mudville) who use the Daylight Saving Time system, put on the same program at exactly the same instant as the people in Mudville do. When they put on the program, their clock points to

A. 6:00 p.m.
B. 7:00 p.m.
C. 9:00 p.m.
D. 10:00 p.m.

Mark your choice on the answer sheet. Then turn this page.

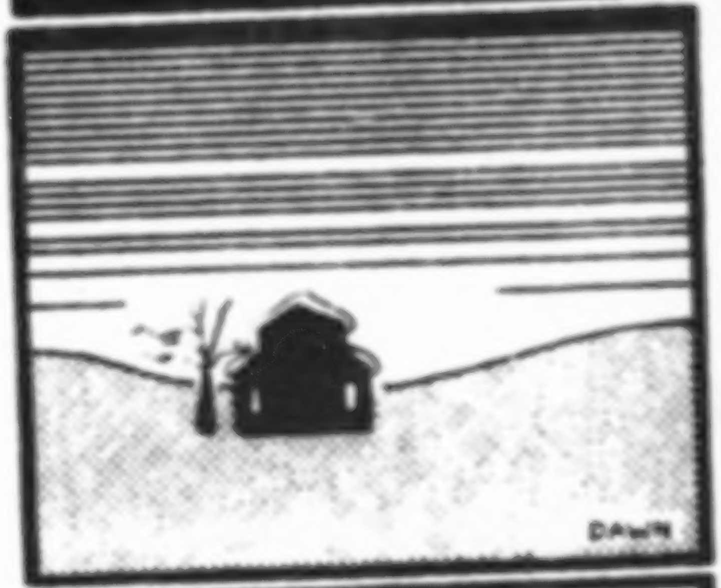


23. In winter when it is 7:30 a.m. Standard Time, it looks like the picture above.

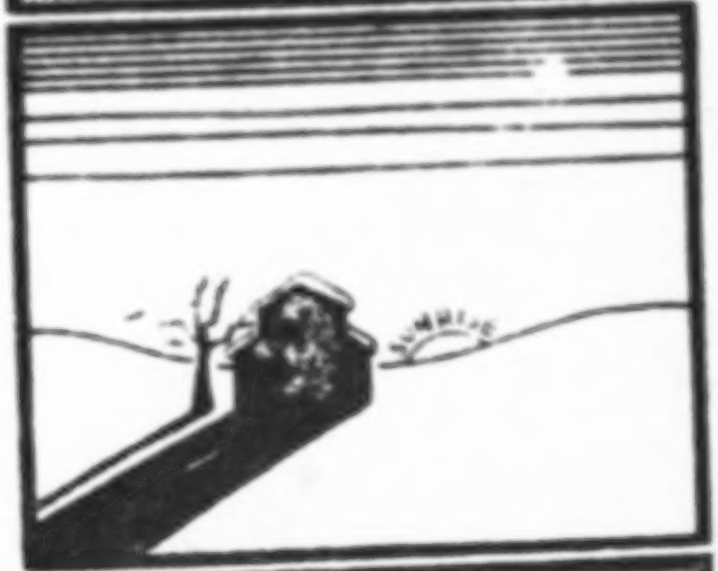
If it was 8:30 a.m. Daylight Saving Time, which of the pictures at the right shows what it would be like?

A

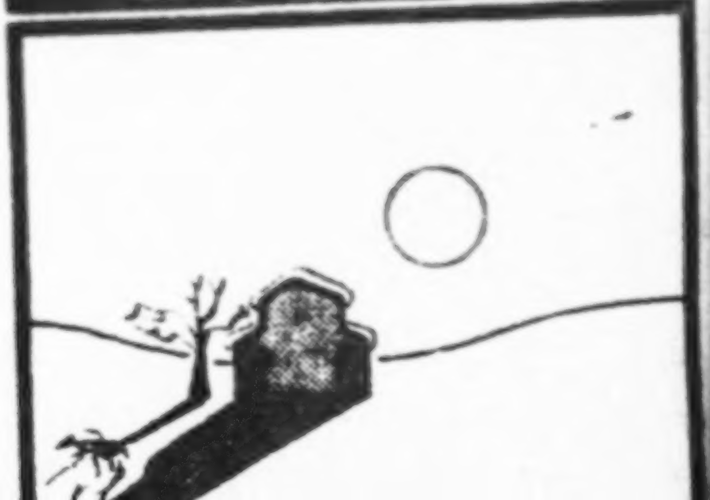
B

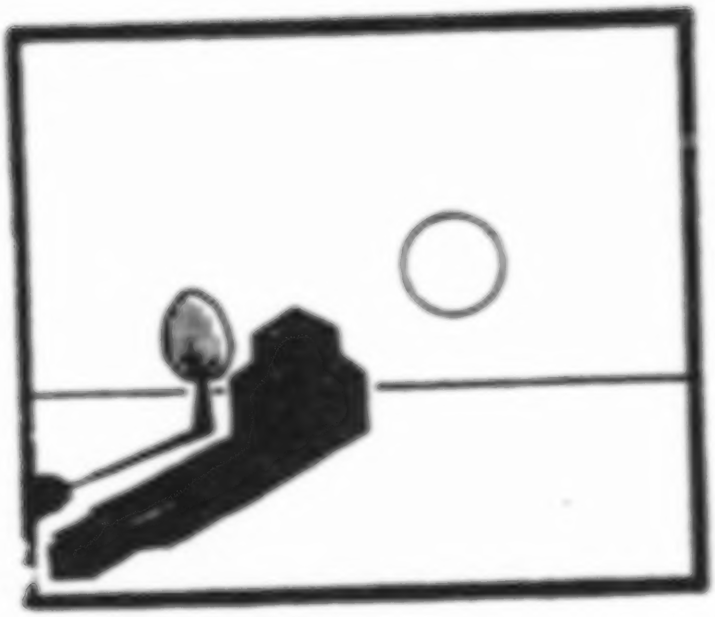


C



D

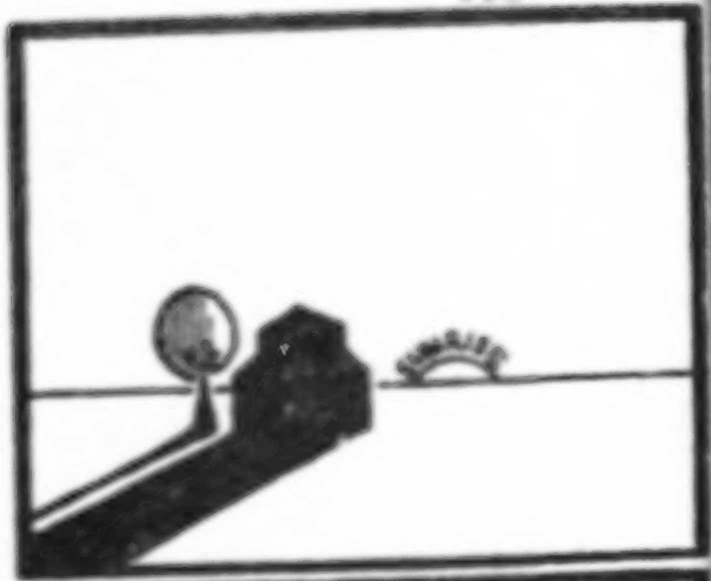




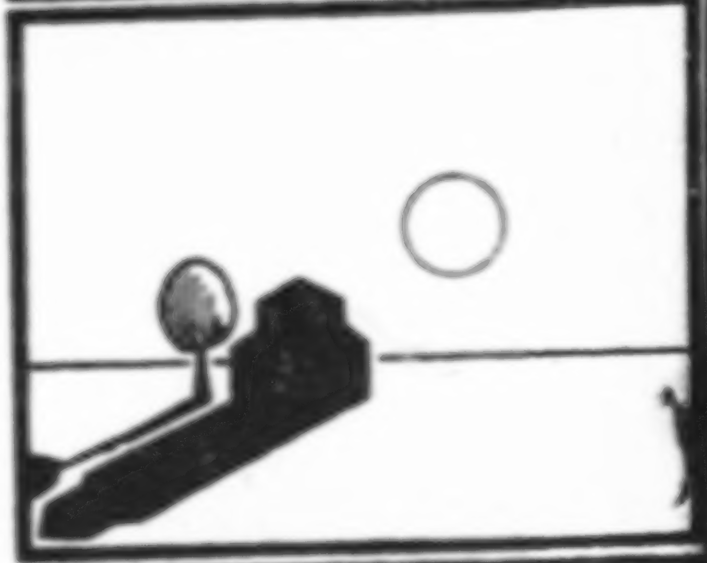
[illegible] In summer, 7:00 a.m. Standard Time looks like the picture above.

If it was 7:00 a.m. Daylight Saving Time, which one of the pictures at the right shows what it would be like?

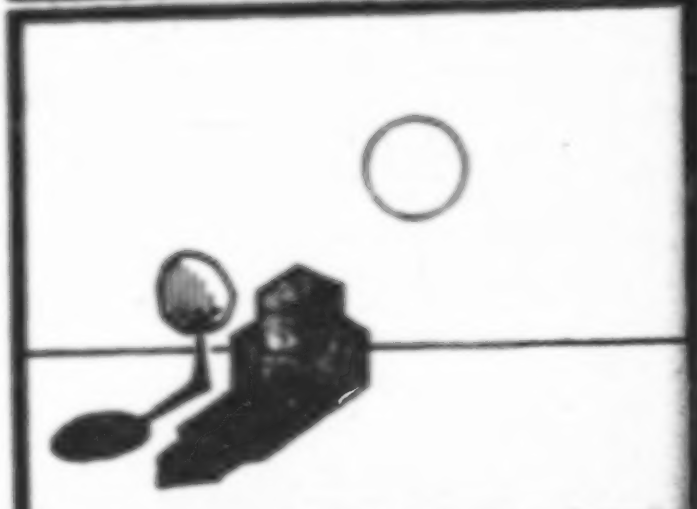
A



B



C



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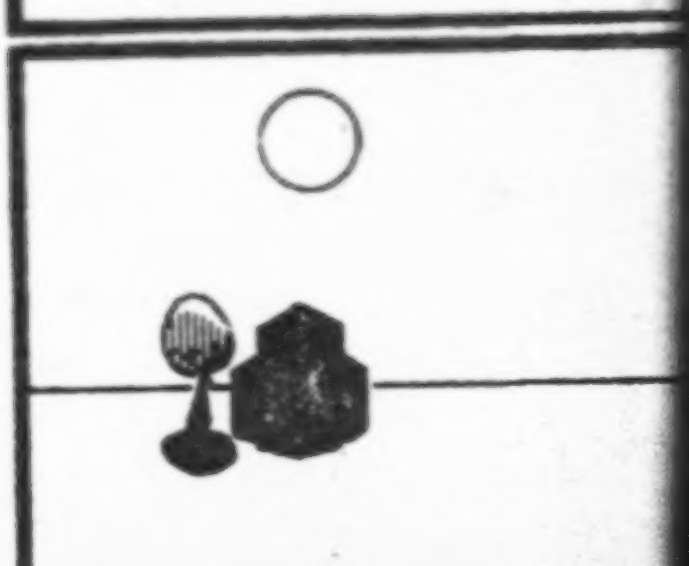
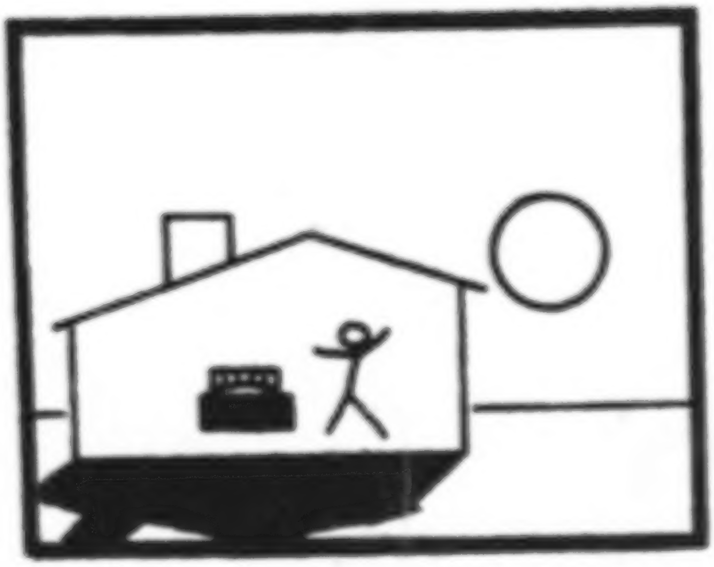
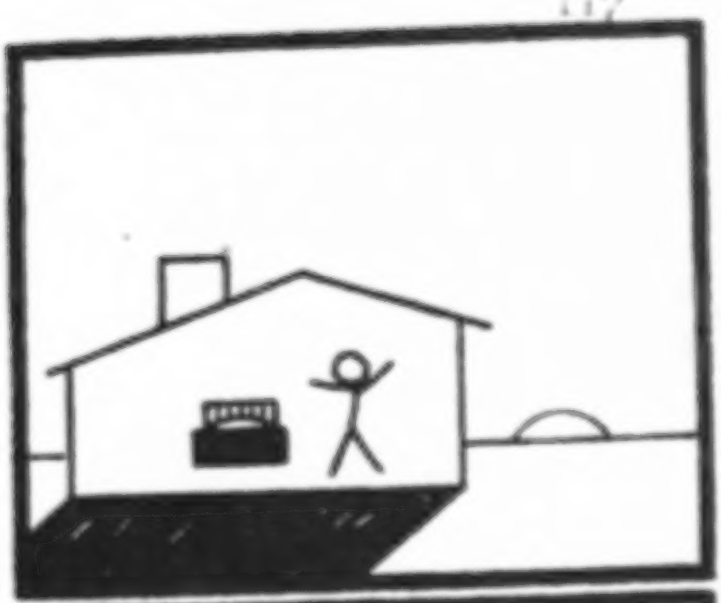




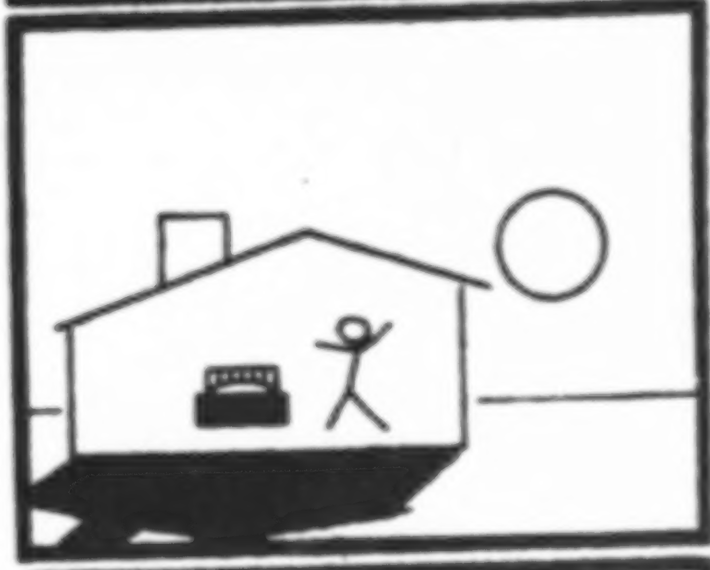
25. It is summer. When Johnny gets up at 7:00 a.m., Standard Time it looks like the picture above.

If Johnny changed to Daylight Saving Time the next day, and did not get up until 9:00 a.m. it would look like which of the pictures to the right?

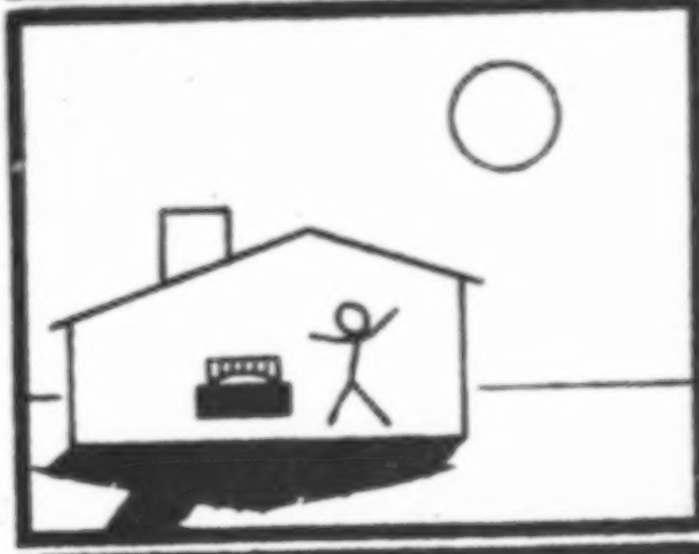
A



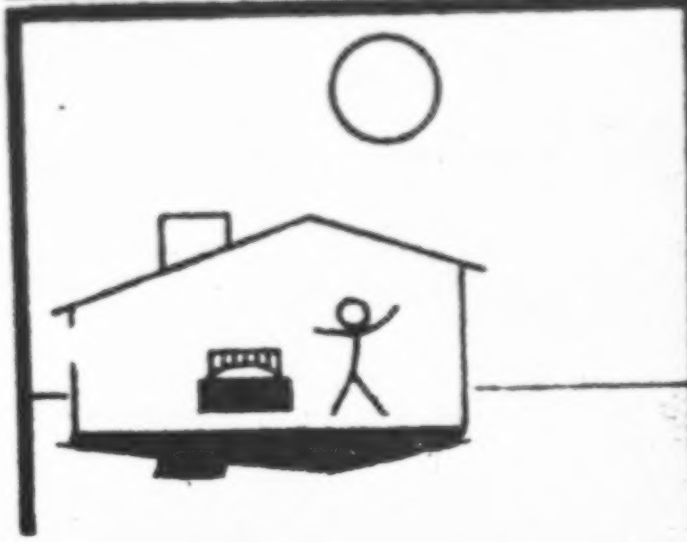
B



C



D



STOP!

DO NOT turn to next page yet.

WAIT till you have seen the next part of the film.

26. The precise length of a day as measured by the sun's position is
    A. slightly more than 24 hours.
    B. slightly less than 24 hours.
    C. sometimes slightly more and sometimes slightly less than 24.
    D. neither A, B, nor C.

Mark your choice on the answer sheet. Then turn this page.

27. In the United States, the time of day is determined from observations made by
    A. Western Union.
    B. the National Bureau of Standards.
    C. the U. S. Naval Observatory.
    D. Radio stations.

Mark your choice on the answer sheet. Then turn this page.

3

28. Official time signals, based on the special clock in the Naval Observatory, are

A. broadcast all over the world by radio stations in every major city.
B. used only aboard ships of the U.S. Navy.
C. used only in this country.
D. broadcast all over the world by a radio station in Washington, D. C.

Mark your choice on the answer sheet. Then turn this page.

29. The radio stations that broadcast official time signals are operated by
   - A. Time Magazine, Inc.
   - B. the National Bureau of Standards.
   - C. the Columbia Broadcasting System.
   - D. the Army Signal Corps.

Mark your choice on the answer sheet. Then turn this page.

30. Many commercial radio and television stations broadcast time signals which are
    A. generally accurate and official.
    B. generally accurate and not official.
    C. inaccurate but official.
    D. inaccurate and not official.

Mark your choice on the answer sheet. Then turn this page.

STOP!

DO NOT turn to next page yet.

WAIT till you have seen the next part of the film.